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No. 1722.] *FRIDAY, NOVEMBER* 20, 1885. [*Vol. XXXIV.*

ONE-HUNDRED-AND-THIRTY-SECOND SESSION, 1885-86.

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SESSIONAL ARRANGEMENTS.

The First Meeting of the One Hundred and Thirty-second Session of the Society was held on Wednesday, the 18th November, when the Opening Address was delivered by Sir Frederick Abel, C.B., D.C.L., LL.D., F.R.S., Chairman of the Council. Previous to Christmas there will be Four Ordinary Meetings, when papers will be read by Professor Silvanus Thompson, Mr F. E. Hulme, and Professor F. Elgar.

ORDINARY MEETINGS.

Wednesday evenings at Eight o'clock. The following dates have been fixed :—

November 25.—Prof. Silvanus P. Thompson, "Apparatus for the Automatic Extinction of Fires."
December 2.—F. Edward Hulme, F.L.S., F.S.A., "Technical Art Teaching."
" 9.—Prof. Francis Elgar, LL.D., F.R.S.E., M.Inst.C.E., "The Loadlines of Ships."
" 16.—*(To be hereafter announced.)*

For Meetings after Christmas:—

Dr. C. Meymott Tidy, "The Treatment of Sewage."
C. V. Boys, "Calculating Machines,"
George Clulow, "The History and Manufacture of Playing Cards."
W. H. Preece, F.R.S., "Domestic Electric Lighting."
Prof. R. Meldola, F.C.S., "The Scientific Development of the Coal Tar Industry."
E. Price Edwards, "The Experiments with Lighthouse Illuminants at the South Foreland."

FOREIGN AND COLONIAL SECTION.

The meetings of this Section will take place on the following Tuesday evenings at Eight o'clock:—

January 26; February 16; March 2, 23; April 13; May 18.

APPLIED CHEMISTRY AND PHYSICS SECTION.

The meetings of this Section will take place on the following Thursday evenings at Eight o'clock:—

January 28; February 11, 25; March 11; April 8; May 13.

INDIAN SECTION.

The meetings of this Section will take place on the following Friday evenings, at Eight o'clock:—

January 22; February 19; March 19; April 2; May 7, 21.

CANTOR LECTURES.

Monday evenings at Eight o'clock:—

The First Course will be on "The Microscope." By John Mayall, Jun.

Lecture I.—November 23.—Origin of the Microscope. Its construction to the date of the application of achromatism. Reflecting Microscopes.

Lecture II.—November 30.—Modern Microscopes. Peculiarities of construction (1) in General Form, and (2) for Special Observations.

Lecture III.—December 7.—Binocular Microscopes. Demonstration Microscopes.

Lecture IV.—December 14.—Objectives, Oculars, and Accessory Apparatus.

Lecture V.—December 21.—The desiderata of a Modern Microscope as exemplified by English, Continental, and American models. Curiosities in Microscope construction.

The Second Course will be on "Friction." By Prof. H. S. Hele Shaw.

Lecture I.—January 18.—The Friction of Solids.

Lecture II.—January 25.—The Friction of Fluids.

Lecture III.—February 1.—The Mechanical Applications of Friction.

Lecture IV.—February 8.—The Methods of Reducing Friction.

The Third Course will be on "Science Teaching." By Prof. F. Guthrie, F.R.S.

Lecture I.—February 15.—Science as an element in Education.

Lecture II.—February 22.—Knowledge about common Stuffs and Things.

Lecture III.—March 1.—Teaching Physics.

The Fourth Course will be on "Petroleum and its Products." By Boverton Redwood, F.C.S.

Lecture I.—March 8.—Historical account of Petroleum, and of the development of the Petroleum industry. Geographical and geological distribution. Chemistry.

Lecture II.—March 15.—Production, Transportation, and Storage of Crude Petroleum. Well drilling. Use of the Torpedo. Pipe-line system. Bulk transportation.

Lecture III.—March 22.—Manufacture of Petroleum products:—Naphtha, Burning Oil, Lubricating Oil, Paraffin. Methods of distillation and purification. Barrel and case making. Testing:—Flashing point, viscosity, lubricating power, melting point.

Lecture IV.—March 29.—The uses of Petroleum and its products. Illumination:—Paraffin candles, mineral oil and spirit lamps, air-gas, natural gas. Heating:—Crude Petroleum and Petroleum residuum as fuel, mineral oil stoves. Natural gas as fuel. Lubrication. Pharmaceutical.

The Fifth Course will be on "The Arts of Tapestry Making and Embroidery." By ALAN S. COLE.

Lecture I.—April 5.—Tapestry making and Embroidery, and their relationship to weaving and to one another. The ornamental character of Tapestries and Embroideries. Comparison of designs and ornamental motives in works of art which have similar forms and intentions. Their development from a common source and their independent development.

Lecture II.—April 12.—Tapestry making as connected with carpet making. The use of Tapestry. Methods of making various Tapestries. Designs in various Tapestries.

Lecture III.—April 19.—Embroidery; its antiquity and connection with costumes, &c. Development of Forms of stitches. Designs in Embroidery.

The Sixth and Concluding Course will be on "Animal Mechanics." By B. W. RICHARDSON, M.A., M.D., F.R.S.

Lecture I.—May 3.—Animal and ordinary Mechanisms considered and compared.
Lecture II.—May 10.—Some details of Animal Mechanisms. The valve, the pulley, and the joint
Lecture III.—May 17.—Some details continued. Animal elasticity and contractility.
Lecture IV.—May 24.—Some special Mechanisms. The animal camera.
Lecture V.—May 31.—Review. In regard to practical applications.

JUVENILE LECTURES.

Two Juvenile Lectures on "Waves" will be given by Prof. SILVANUS P. THOMPSON, D.Sc., on Wednesday evenings, December 30, 1885, and January 6, 1886.

Lecture I.—December 30.—Air Waves and Water Waves.
Lecture II.—January 6.—Ether Waves and Electric Waves.

PROCEEDINGS OF THE SOCIETY.

CHARTER.—THE SOCIETY OF ARTS was founded in 1754, and incorporated by Royal Charter in 1847, for "The Encouragement of the Arts, Manufactures, and Commerce of the Country, by bestowing rewards for such productions, inventions, or improvements as tend to the employment of the poor, to the increase of trade, and to the riches and honour of the kingdom; and for meritorious works in the various departments of the Fine Arts; for Discoveries, Inventions, and Improvements in Agriculture, Chemistry, Mechanics, Manufactures, and other useful Arts; for the application of such natural and artificial products, whether of Home, Colonial, or Foreign growth and manufacture, as may appear likely to afford fresh objects of industry, and to increase the trade of the realm by extending the sphere of British commerce; and generally to assist in the advancement, development, and practical application of every department of science in connection with the Arts, Manufactures, and Commerce of this country."

THE SESSION.—The Session commences in November, and ends in June. The number of Meetings held during the Session amounts to between 70 and 80.

ORDINARY MEETINGS.—At the Wednesday Evening Meetings during the Session papers on subjects relating to inventions, improvements, discoveries, and other matters connected with the Arts, Manufactures, and Commerce of the country are read and discussed.

INDIAN SECTION.—This Section was established in 1869, for the discussion of subjects connected with our Indian Empire. Six or more Meetings are held during the Session.

FOREIGN AND COLONIAL SECTION.—This Section was formed in 1874, under the title of the African Section, for the discussion of subjects connected with the Continent of Africa. It was enlarged in 1879, so as to include the consideration of subjects connected with our Colonies and Dependencies, and with Foreign Countries. Six or more Meetings are held during the Session.

APPLIED CHEMISTRY AND PHYSICS SECTION.—This Section was formed in 1874, for the discussion of subjects connected with Practical Chemistry and its applications to the Arts and Manufactures. It was enlarged in 1879, so as to include the consideration of subjects connected also with the Applications of Physical Science to the Arts. Six or more Meetings are held during the Session.

CANTOR LECTURES.—These Lectures originated in 1863, with a bequest by the late Dr. Cantor. There are several Courses every Session, and each course consists generally of from Three to Six Lectures.

ADDITIONAL LECTURES.—Special Courses of Lectures are occasionally given.

JUVENILE LECTURES.—A short Course of Lectures, suited for a Juvenile audience, is delivered to the Children of Members during the Christmas Holidays.

ADMISSION TO MEETINGS.—Members have the right of attending the above Meetings and Lectures. They require no tickets, but are admitted on signing their names. Every Member can admit *two* friends to the Ordinary and Sectional Meetings, and *one* friend to the Cantor and other Lectures. Books of tickets for the purpose are supplied to the Members, but admission can be obtained on the personal introduction of a Member. For the Juvenile Lectures special tickets are issued.

JOURNAL OF THE SOCIETY OF ARTS.—The *Journal*, which is sent free to Members, is published weekly, and contains full Reports of all the Society's Proceedings, as well as a variety of information connected with Arts, Manufactures, and Commerce.

EXAMINATIONS.—Examinations are held annually by the Society, through the agency of Local Committees, at various centres in the country. They are open to any person. The subjects include the principal divisions of a Commercial Education, Political and Domestic Economy, and Music. A Programme, containing detailed information about the Examinations, can be had on application to the Secretary.

LIBRARY AND READING-ROOM.—The Library and Reading-room are open to Members, who are also entitled to borrow books.

CONVERSAZIONI are held, to which the Members are invited, each Member receiving a card for himself and a Lady.

MEMBERSHIP.

The Society numbers at present between three and four thousand Members. The Annual Subscription is Two Guineas, or a Life Subscription of Twenty Guineas may be paid.

Every Member whose subscription is not in arrear is entitled :—

To be present at the Evening Meetings of the Society, and to introduce two visitors at such meetings, subject to such special arrangements as the Council may deem necessary to be made from time to time.
To be present and vote at all General Meetings of the Society.
To be present at the Cantor and other Lectures, and to introduce one visitor.
To have personal free admissions to all Exhibitions held by the Society at its house in the Adelphi.
To be present at all the Society's *Conversazioni*.
To receive a copy of the Weekly *Journal* published by the Society.
To the use of the Library and Reading-room.

Candidates for Membership are proposed by three Members, one of whom, at least, must sign on personal knowledge; or are nominated by the Council. The Annual Subscription is Two Guineas, payable in advance, and dates from the quarter-day immediately preceding election; or a sum of Twenty Guineas in lieu of all further contributions, may be paid.

All subscriptions should be paid to the Secretary, H. T. Wood, and all Cheques or Post-office Orders should be crossed "Coutts and Company," and forwarded to him at the Society's House, John-street, Adelphi, London, W.C.

NOTICES.

◆

APPLIED CHEMISTRY & PHYSICS SECTION.

A meeting of the Committee of this Section was held Monday, 16th inst., at 4 p.m. Present:—Sir Frederick A. Abel, C.B., F.R.S., Chairman of Council (in the chair), Mr. W. Anderson, Mr. G. Matthey, F.R.S., with Mr. H. Trueman Wood, Secretary, and Mr. J. M. Thomson, Secretary of the Section. The programme of papers to be read during the session was discussed.

Proceedings of the Society.

◆

FIRST ORDINARY MEETING.

Wednesday, November 18th, 1885; Sir FREDERICK ABEL, C.B., D.C.L., F.R.S., Chairman of the Council, in the chair.

The following candidates were proposed for election as members of the Society:—

Adames, Cornelius George, Pembroke-house, London-road, Kingston, Portsmouth.
Barrow, Samuel, jun., Fontainebleu, Dacres-road, Forest-hill, S.E.
Bassano, Alexander, 25, Old Bond-street, W., and 12, Montagu-place, Bryanston-square, W.
Beck, Joseph, 68, Cornhill, E.C.
Binns, Richard William, Royal Porcelain Works, Worcester.
Bishop, Frank, 22, Soho-square, W.
Blair, Thomas Edward, Royal Army Clothing Depôt, Grosvenor-road, S.W.
Bond, Henry Cooper, Westwood, Ipswich.
Boys, Admiral Henry, East Dean, Kidbrook-park-road, Blackheath, S.E.
Brinsmead, John, 18, Wigmore street, W.
Bromhead, S. S., The Birches, Jasper-road, Upper Norwood, S.E.
Brown, Joseph, Savile Town, Dewsbury.
Burnett, Cuthbert, Burn-terrace, Hartlepool.
Candy, Frank, Leigh-house, Leigh-road, Highbury, N.
Capel, Charles Cecil, North Cray-place, Foot's Cray, Kent.
Carbutt, Edward Hamer, Llanwern-house, near Newport, Monmouthshire.
Carey, Arthur, 56, Talgarth-road, West Kensington, S.W.
Carver, James, Garfield-house, Nottingham.
Chater, John, 89, Fleet-street, E.C.
Clowes, William Charles Knight, M.A., Duke-street, Stamford-street, S.E.
Cohen, Nathaniel Lewis, 3, Devonshire-place, Portland-place, W., and Round Oak, Englefield-green, near Staines.
Colby, William Henry, Oak Leigh, Denbigh, North Wales.
Converse, Fred B., 8, Holborn-viaduct, E.C.
Copeland, Major Alfred James, Bridewell Royal Hospital, Blackfriars, E.C.
Corbett, Edward, jun., Ruabon, North Wales.
Cox, John, Hunstanton, St. Edmunds.
Crabb, William, Silloth, Cumberland.
Crofton, Rev. William d'Abzac, M.A., Hillside, Welwyn, Herts.
Crookes, William, F.R.S., 7, Kensington-park-gardens, W.
Curtis-Hayward, Arthur Cecil, Lonsdale-chambers, 27, Chancery-lane, W.C.
Cutler, George Benjamin, 4, Westcombe-park, Blackheath, S.E.
Crozier, Mrs. (Laura), Grafton-house, Grafton-square, Clapham, S.W.
Dornbusch, Ernest G., 35, Stapleton-hall-road, Crouch-hill, N.
Durham, Arthur Edward, F.R.C.S., 82, Brook-street, Grosvenor-square, W.
Drysdale, Mrs. J. Dockar, 39, Belsize-park, N.W.
Edmonds, James, 67, Baker-street, W.
Edgell-Hunt, H., 8, St. Mary Abbott's-terrace, Kensington, W.
Elborough, Alfred Louis, Bedford-park, Croydon.
Ellis, Lieut.-Colonel C. H. Fairfax, R.A., 7, Palace-gardens-terrace, Kensington, W.
Erle, Twynihoe William, 1, Cambridge gate, Regent's-park, N.W., and Cuckfield, Sussex.
Essex, Richard Walter, Abbottsford, Thirlemere-road, Streatham, S.W.
Eve, Richard Wafford, M.B., M.R.C.S., 101, Lewisham High-road, S.E.
Foster, Herbert A., Queensbury, near Bradford, Yorks.
Gadsden, Henry Arthur, 6, Crosby-square, E.C.
Gardner, Henry Dent, 25, Northbrook-road, Lee, S.E.
Gates, J. S., 9, Fenchurch-avenue, E.C.
Gay, Frederick William, 113, High Holborn, W.C.
Gray, Thomas, C.B., Board of Trade, Whitehall, S.W.
Greenbank, Richard Hewetson, 18, Leamington-road-villas, Westbourne-park, W.
Grevel, Hermann, 33, King-street, Covent-garden, W.C.
Griffitt, John, Bournabat, near Smyrna, Asia Minor.
Hamilton, Alfred G., Grosvenor-hill, Wimbledon, Surrey.

Haycraft, Alfred Conyers, Westcourt, Lewisham-hill, S.E.
Heath, George, 107, Oxford-street, W.
Heyland, E. Douglas, 25, Liverpool-street, E.C., and 15, Maze-hill, Greenwich, S.E.
Hill, Robert Anderson, Royal Mint, E.
Holt, William Lyster, 17, Parliament-street, S.W.
Honywood, Thomas, Courtenay-house, The Causeway, Horsham.
Innes, John, Greenfield-villas, Llanelly, Camarthenshire.
Jackson, William Lawies, Allerton-hall, Leeds.
Jacobs, Reuben, 1, Sheldon-street, Bayswater, W.
Jobling, Thomas Edgar, Croft-villa, Blyth, Northumberland.
Kemp, Dixon, 39, Palace-gardens-terrace, Kensington, W.
Kesterton, Vicesimus, 56, Seymour-street, W.
Knowles, Henry, The Shrubbery, Woodville, Burton-on-Trent.
Lawford, George, Sherbrooke-lodge, Nightingale-lane, Balham, S.W.
Lawford, John Eeles, 7, Mowbray-road, Brondesbury, N.W.
Lickorish, Sidney, 17, Highbury-hill, N.
Lyster, George Fosbery, Gisburne-house, Liverpool.
Mac Gauvan, Francis, Salisbury Club, St. James's, S.W.
Maling, Christopher T., 14, Ellison-place, Newcastle-on-Tyne.
Marshall, Julian, 13, Belsize-avenue, N.W.
Masters, W. F., Shenley-lodge, Acre-lane, Brixton, S.W.
Mawe, Frederic H., Willow-grove, Chislehurst, Kent.
Mayne, James, 203, Oxford-street, Sydney, New South Wales.
Medhurst, Sir Walter Henry, Formosa, Kent's-road, Torquay, Devon.
Milne, John Vine, B.A., Henley-house, Mortimer-road, St. John's-wood, N.W.
Milner, Edward, 32, New Cavendish-street, W.
Mordey, William Morris, 144, Disraeli-road, Putney, S.W.
Morgan, Major Joseph Bond, Stand-house, Childwall, Liverpool.
Mylne, Henry Charles, 37, Ebury-street, S.W.
Newton, Henry Edward, 6, Bream's-buildings, Chancery-lane, E.C.
Owen, Thomas, Ellsbridge-house, Keynsham, near Bristol.
Oxley, Frederick, 8, Crosby-square, E.C.
Palmer, Henry, East Howle, Ferryhill, Durham.
Pam, Leopold, 4, Holborn-circus, E.C., and Bohemian-villa, Clapham-park, S.W.
Pennsylvania Museum and School of Industrial Art, Fairmount-park, Philadelphia, U.S.A.
Pixley, Stewart, 21, Leinster-gardens, Hyde-park, W.
Price, Samuel, 38, Walbrook, E.C.
Ramsden, Frederick Frank, Arthur's Club, S.W., and Uffington Rectory, Stamford.
Ramsden, Joseph, The Lion Brewery, Lambeth, S.E.
Redrup, Sidney, Park-street, Windsor.
Riordan, T. Vincent, 1, Whiteley-road, Upper Norwood, S.E.
Robertson, James, 21, Berners-street, W.
Rooper, Maximilian George, 6, Kensington-gardens-square, W.
Schipper, J. F., 10, King-street, Covent-garden, W.C.
Schreiber, Richard, Bloomsbury-mansions, Hart-street, W.C.
Shipley, Mrs. R., Acacia-house, 186, Brixton-road, S.W.
Simpson, Thomas, Silbury-villa, Ravenscroft-road, Beckenham, Kent.
Smith, Sebastian, Shipley Collieries, Derby.
Smithe, Joseph Doyle, 11, Delamere crescent, W.
Stanley, Christopher Philip, 6, Sussex-villas, Faraday-road, Leyton, Essex.
Temple, Captain R. C., Naval and Military Club, 94, Piccadilly, W., and The Elms, Porchester-gardens, Hyde-park, W.
Testard, Henry, 53, Blackheath-road, Greenwich, S.E.
Thomasson, Ebbe Salvinius, Messrs. Ibbotson Bros., and Co., Limited, Globe Works, Sheffield.
Thompson, A. M., Rossmore, Chislehurst-road, Sidcup, Kent.
Tress, Cooper, West-lodge, Clapham-park, S.W.
Viner, L. L., 54, Westbourne-grove, W.
Waine, Thomas Glover, 139, Newington-butts, S.E.
Waterworth, Alfred, Thorncliffe, Fulwood-park, Preston.
Webster, Charles S. Stanford, Malvern-house, Redland, Bristol.
Welling, Gysbertus, 10, County-grove, Camberwell, S.E.
Winser, Frederic Sawyer, 52, Buckingham-palace-road, S.W.

And as an Honorary Corresponding Member:—

Landreth, Burnet, 21, South Sixth-street, Philadelphia, U.S.A.

The CHAIRMAN delivered the following

ADDRESS.

The address to which the members of the Society of Arts were so good as to afford a favourable reception at the opening meeting of last Session, was in great measure devoted to topics suggested by the International Health Exhibition of that year. Wide as was the scope of that Exhibition, which dealt not only with the necessaries and comforts of life, and the promotion of bodily health in the feeding, clothing, and housing of all classes, but also with the all-important subjects of physical and mental training, the Exhibition of Inventions—which has just terminated a prosperous and, I believe, a very useful career—was certainly not less comprehensive, in regard to the number of subjects which it embraced. The thirty-one groups, comprising no less than 165 more or less extensive classes of subjects, in connexion with which were exhibited inventions or improvements originated or practically applied since 1862, constituted a wealth of material for study which could bear comparison, as regards extent and interest, with that presented by any one of the great International Exhibitions of former years, the initiation of which we owe to that illustrious Prince whose memory the Society of Arts delights to honour.

I have resisted the temptation, which was strong upon me, to devote this evening to a brief review of some of the chief matters of interest presented by the most prominent sections of the Exhibition, because I entertain a lively hope that a thorough examination of at any rate many of these will afford topics for important communications to this Society, and I consequently feel that it might be detrimental to the interest presented by such papers, and scarcely just to those who may consent to devote themselves to their preparation, were I to cull specially attractive matter from the mass of information opened up to the student by the achievements demonstrated at the Exhibition. I have, therefore, coerced myself into modest action on the present occasion, and I propose to initiate a mode of treatment of the topics presented for study by the late Exhibition, which I hope may be of benefit to our members, and perhaps to the public at large, by dealing in this address only with some matters relating to one branch of a division of the Exhibition, namely, the class which deals with machinery and appliances used in mines.

I venture to think that this class of subjects has claims to special interest, because the mining industry ranks among the most important sources of the wealth and cosmopolitan influence of the empire; because its development and successful pursuit have involved the utilisation of the resources of many branches of applied science, and have taxed the talents and ingenuity of some of our greatest mechanics and most accomplished physicists and chemists; and, though last not least, because the pursuit entails the encountering of dangers and vicissitudes which will aptly bear comparison with those involved in the careers of a soldier and a sailor. Thrilling and harrowing accounts of great disasters in coal mines direct public attention from time to time to certain special dangers which the miner has to encounter, but the annual reports of H.M. Inspectors of Mines show that there are yet other dangers to which miners in general are daily exposed, which, although they do not attract public attention, partly because of the very circumstance of their constant occurrence, and partly because the sufferers by them meet their deaths in most cases singly, are, nevertheless, very decidedly more formidable, in regard to the gross extent of the fatalities attending them, than are coal-mine explosions.

When the late Mr. Macdonald, M.P. for Stafford, made his remarkable speech in the House of Commons, in 1878, advocating the necessity for the more rigorous inspection of coal mines, and supported his arguments with the enumeration of an appalling list of colliery explosions, attended in most cases by the loss of many lives, it was pointed out by Mr. Thomas Burt, and some other members who took part in the subsequent interesting debate, that explosions did not constitute the chief element of danger which the miner had to encounter, and that, while out of 25,000 lives which had been lost in mines since 1851, over 6,000 deaths had been caused by explosions, there were more than 10,000 due to falls of stone and coal in the mine workings, which attracted little or no attention. Mr. Cowen also called attention to the fact that there was a still larger number of injuries, due to such causes as these, which were never heard of beyond the locality of the disasters, because they were not attended with fatal results, although in the larger proportion of such cases the sufferers were either maimed for life, or died after more or less brief intervals. The following Table (p. 8) which has been compiled from the annual reports of the Mine Inspectors for the past ten years, shows the total number of deaths annually due to accidents in mines, and the deaths due respectively to explosions, to the falls of roof or sides in mine workings, and to other miscellaneous causes; and it will be seen that even in those years when especially disastrous explosions had occurred, causing the deaths of scores or hundreds of men, the fatalities due to them were, with the exception of two years, considerably in the minority compared with deaths from falls of roof and sides, while, comparing them with the deaths due to all other causes, the latter were invariably much in excess, being from about 1·5 to 13 times greater in number than the deaths from explosions*.

It is not surprising, however, that the paralysing moral effect exercised upon small mining communities, and the heartrending local misery and suffering which suddenly and simultaneously fall upon many families, should

STATEMENT OF PROPORTION OF DEATHS FROM EXPLOSIONS IN COAL MINES, FROM FALLS OF ROOF AND SIDES, AND FROM OTHER MISCELLANEOUS CAUSES, TO TOTAL DEATHS IN MINES FROM ALL CAUSES, DURING THE YEARS 1875–1884.

Year.	Total Number of Deaths from Accidents of all kinds.	No. of Deaths from			Results of some of the more disastrous Explosions in each year.		
		Explosions of Fire-damp.	Roof and Sides falling.	Other causes.			
1875	1,244	288	459	497	Explosion at the Swaithe Main Colliery, near Barnsley	143	lives lost.
					,, Bunker's Hill Colliery, Stoke-on-Trent	43	,,
					,, New Tredegar Colliery, Monmouthshire	23	,,
					,, Llan Colliery, near Cardiff	16	,,
1876	933	95	449	389	,, South Wales Colliery, Abertillery	23	,,
1877	1,208	345	448	415	,, Blantyre Colliery	207	,,
					,, Pemberton Colliery, near Wigan	36	,,
1878	1,413	586	469	358	,, Abercarn Colliery, Monmouthshire	268	,,
					,, Wood Pit, Haydock	189	,,
					,, Apedale Colliery	23	,,
					,, Barwood Colliery, Kilsyth, near Glasgow	17	,,
1879	992	203	426	363	,, Dinas Colliery, Pontypridd	63	,,
					,, Blantyre Colliery	28	,,
					,, Stanley Colliery, near Wakefield	21	,,
1880	1,318	499	462	357	,, Seaham Colliery	164	,,
					,, Risca Colliery	120	,,
					,, Penygraig Colliery	101	,,
					,, Leycett Colliery	62	,,
1881	954	116	450	388	,, Abram Colliery, Wigan	48	,,
					,, Whitfield Colliery, Tunstall	25	,,
1882	1,126	250	468	408	,, Trimdon Grange Colliery, Durham	74	,,
					,, Tudhoe Colliery, Durham	37	,,
					,, Clay Cross Colliery, Derbyshire	45	,,
					,, Baddesley Colliery, Warwickshire	23	,,
					,, West Stanley Colliery, Chester le-Street	13	,,
1883	1,054	134	469	451	,, Altham Colliery, Lancashire	68	,,
					,, Wharncliffe Carlton Colliery, near Barnsley	20	,,
1884	942	65	482	395	,, Pochin Colliery, near Tredegar, Monmouthshire	14	,,
					,, Naval Steam Coal Colliery, Penygraig	14	,,

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* The facts embodied in the above Table have been long accessible to all who care to inform themselves correctly, by reference to the published annual reports of H.M. Mine Inspectors; it is, therefore, somewhat surprising to find the Manchester correspondent of the *Times*, to whose views that journal appears to attach much weight, and whose evident acquaintance with high authorities in matters relating to coal mines, such as Mr. Ellis Lever, should have, at any rate, assisted him to a knowledge of the existence of those reports, is ignorant of the truth relating to a subject with which he deals in a fashion somewhat over-authoritative for the representative of "unenlightened earnestness," which is "impatient" to learn the reason for "hesitation" on the part of a Royal Commission on mine accidents in promulgating its conclusions, is "incredulous of the difficulty of speaking out," and indignantly regards "the delay as a national scandal." In support of this somewhat strong expression of sentiment, "unenlightened earnestness" inquires whether it has "really needed so long to dispel any doubt that shot-firing, for instance, is the commonest cause of the loss of life in coal mines."

cause coal-mine explosions to command special sympathy, and to call forth public expressions of regret and surprise that the resources of science and of legislative power should have failed utterly to prevent, or even very greatly diminish, such sad disasters; while, on the other hand, the daily occurrence of fatal accidents in the ordinary pursuit of the miners' vocation attracts little public attention, although it receives at the hands of those who study the official reports of mining casualties the serious consideration which it equally merits. It has been contended that the classes of minor and constantly recurring accidents, which combine to cause a far more formidable total of deaths than even an unusual succession of serious explosions, are to a great extent made up of unavoidable sources of danger to which the miner must be exposed; and that, on the other hand, the causes which lead to explosions have been long known, and can be readily grappled with and removed by the colliery owner or manager. That the former is the case, as regards, at any rate, the greater proportion of the smaller accidents, can however, be as little admitted as that it would have been possible in the past to attain to security against explosions by perfection of ventilation, by the prohibition of the use of explosives in so-called fiery mines, and by the exclusion of naked lights from localities where fire-damp is known to exist, or is liable to make its appearance. The nature of some of the chief and most prevalent conditions favourable to mine explosions is, in fact, only now being thoroughly established and made clear, and the same may be said of the nature of measures and appliances by which explosions may be avoided or diminished in magnitude, and comparative safety in working made compatible with a reasonably profitable encounter of the difficulties attendant on the getting of coal, which are continually increasing as the exhaustion of our supplies is approached.

From the foregoing considerations, it is evident that very great interest and importance must attach to any decided improvements in systems of working, or in appliances connected with mining, and bearing directly upon the safety, facility, and degree of comfort from a sanitary point of view, with which subterranean operations can be carried on, and upon the general welfare of that considerable proportion of the country's population composed of the toilers underground. The members of the Society of Arts will, therefore, I feel sure, take a lively and sympathetic interest in the statements and observations which I have to offer in connection with the Mining Section of the late Exhibition, and, in reference to the labours, now fast drawing to a close, of a Commission, appointed by her Majesty about six and a half years ago, to inquire and report whether the resources of science could furnish any practical expedients, not then in use, which might be calculated to prevent the occurrence of accidents in mines, or to limit their disastrous consequences; a Royal Commission whose earnest and disinterested labours have been patiently, steadily, and faithfully pursued to successful issues, in spite of engrossing official public and professional duties, and undeterred by the public censure and abuse with which the persevering efforts of its members to complete, as far as practicable, the heavy task allotted to them, have as yet been alone encouraged.

The display at the recent Exhibition of implements and appliances connected with mining, though not extensive, was yet sufficiently comprehensive to be fairly representative of the nature of improvements which have of late been accomplished in boring and drilling machines, in miners' tools, in haulage and hoisting machinery, and the provision of power underground, in appliances for preventing accidents in connection with the lowering and raising the cages, in the mechanical appliances for coal-getting, in proposed substitutes for explosives, and in means for safe underground illumination. Some of the exhibits included under these heads demonstrate very important progress made since the Accidents in Mines Commission commenced their labours, and are traceable in several directions to certain results of those labours, which, though not formally communicated to the public in the shape of Reports, have become known to many who are actively engaged in the management and supervision of mines.

In the preliminary report of the Accidents in Mines Commission, published in 1881, it was pointed out that the great advance which had been made in the previous thirty years in the reduction of the death-rate in mines, the number of persons employed having been nearly doubled, while the total number of deaths remained about the same, was due not merely to improved legislation connected with mines, but also to the spirit of inquiry and emulation fostered by local scientific Institutes of mine managers and mining engineers. These Institutes, among which the North of England and the Midland Institutes of Mining and Mechanical Engineers may be specially mentioned, have continued to labour actively for the advancement of knowledge bearing upon the reduction of danger in mines, not only by the reading and discussion of papers, but also by the prosecution of systematic experiments on the relative merits of safety lamps and other matters intimately connected with the experimental work which the Commission has been at the same time pursuing, and the results arrived at have been most valuable, as contributing to and confirming important conclusions which have been arrived at.

The preliminary report of the Commission consisted to a great extent of a summary of a large mass of evidence taken by them from the inspectors of mines, from experienced colliery owners and mining engineers, and from a number of workmen selected for the purpose by the miners' associations. An examination of that evidence showed that there were several important subjects connected with the safe and efficient working of mines upon which large differences of opinion prevailed, even among those who combined great practical experience with scientific knowledge of no mean order. This was especially the case with reference to the employment of naked or open lights in mines, the relative merits of well-known safety lamps, the uses of gunpowder or other explosives underground, and the possible influence of coal-dust in the development or extension of explosions. It was, therefore, especially in these directions that the Commissioners considered it their paramount duty to pursue experimental inquiries, and, as those investigations proceeded, their importance and the useful results likely to emanate from them became the more apparent, while each succeeding step demonstrated the necessity for proceeding further in the inquiries, so that, even up to this the period fixed by them for the completion of their final report, the Commissioners have found themselves still engrossed in experiment.

Without presuming to deal in anticipation with the conclusions arrived at by my colleagues and myself as the results of our protracted investigation, I may venture, in touching upon the chief points of interest suggested by the Mining Section of the Inventions' Exhibition, to indicate the nature of some of those results sufficiently to illustrate the progress which has been made in certain matters most vitally affecting the safety of the miner.

The important advances which have of late been made in the methods of operation and mechanical appliances provided for exploring and for breaking ground, were illustrated in the Exhibition by some of the most recent improvements in boring and drilling machines, and in the construction of the more ordinary hand tools. Without dwelling upon the marked advance which has been made in the operations of deep boring and of tunnel driving, by combining the utilisation of steam or compressed air with the method of continuous flushing, by replacing the solid rods and sludge pumps by hollow rods and continuous water circulation for the removal of detritus, special reference must be made to the great improvement effected in mining operations by the use of drills or perforators driven by compressed air, of which six varieties were shown, representing only a small proportion of the various forms of mechanical drills introduced into practice during the last twenty years. Considerable improvements have also been made in hand-drilling machines, which, supplemented by the employment of wedges, have been used successfully for bringing down coal or rock in some localities where fire-damp is prevalent. These drills, of which that exhibited by Messrs. Asquith and Ormsby appears to be a very efficient form, are mounted upon wrought iron standards which are firmly wedged between floor and roof, and are worked by a ratchet-bar or a winch-handle (the Asquith drill being worked by an endless chain, which enables a hole to be bored close to the roof); a long taper steel wedge is then introduced between two side clips or "feathers," and is driven home by blows from a sledge hammer; or the wedge is forced in between the feathers by the operation of a screw-bar. Here, again, Messrs. Asquith and Ormsby have achieved comparatively considerable success, by the application of an efficient modification of the plug and feathers system of wedging. So-called coal-cutting machines, for holing or undercutting coal, of which many forms have constituted prominent features in the mining sections of former exhibitions, were only represented by one variety on the present occasion, and appear to have hitherto made little way, although their use would seem to be attended with some decided advantages. Hydraulic pressure has been applied with some degree of success in connection with drilling machines and with the forcing down of coal; thus Mr. Chubb has applied the hydraulic press to the working of a range of pistons placed inside the holes; Messrs. Bidder and Jones used a long wedge in a similar manner, in some apparently successful work in South Wales and the Potteries; and more recently, Messrs. Dubois and Francois, who exhibited their apparatus at last year's Health Exhibition, have applied a very efficient hydraulic arrangement, called the *Bossoyeuse*, with considerable practical success at Blanzy near Liége, for the last three years, to the removal of rock or stone in mines where fire-damp exists. The method of operation is very simple. A number of holes, grouped together in a particular manner, are bored by means of drills actuated by compressed air, and plug and feather wedges are then driven into the holes by means of an hydraulic ram. The rapidity with which rock is thus removed is stated to compare even favourably with gunpowder.

I should fear to be led too much into detail were I to refer to the different methods of working seams of coal, which have been subject to but few modifications of late, and to the variety of circumstances which determine their expediency or relative merits in different cases, or of opinions entertained by advocates of each particular system. I will limit myself, therefore, to the statement that the so-called *long wall* system, which consists in the continuous excavation of the coal throughout or along a considerable distance of the breadth of the seam, the excavated part being filled up, as the work advances, with stone and slack, or with material brought from the surface, presents facilities for securing efficient ventilation, and other advantages in regard especially to the safety of the workmen, by which it recommends itself for choice wherever it is applicable, and more especially in districts where fire-damp prevails, it being decidedly the safest method of working, both because of the facilities it affords for effective ventilation, and because it entails less liability to accidents from falls of coal, &c., than other systems of working.

The large proportion which, with rare exceptions, accidents arising from falls of roof and sides in mine-workings bear to casualties of all other descriptions, should render the subject of their possible diminution a matter for anxious and constant consideration and study at the hands of those connected with the management of coal and mineral mines. The tendency to a sudden dislodgment or giving way of the roof or sides of a working depends upon a considerable variety of causes, such as the conditions under which different seams, beds, or veins, over or under-lying each other, are worked, the inclination at which they are found, the character of stone or mineral composing the floor and roof of the mine. Sometimes there are slips or cleavages intersecting the seam, and running up into the roof; in other cases comparatively loose masses, or "balls," of ironstone are irregularly interspersed in a bed or seam, and may become suddenly detached from the roof, their presence having been unsuspected; or sometimes, when seams are worked close together, great pressure may be brought to bear upon the floor or sides, and the roof may suddenly yield in consequence.

An examination of the Mines Inspectors' Casualty Returns, and of evidence given before the Royal Commission by Mr. Dickinson, Chief Inspector of Mines, happily shows that although, at first sight, the deaths from the falls of roofs and sides appear to form a larger proportion of the total deaths in mines than they did thirty years ago, a considerable improvement has actually taken place in the death-rate from falls during the last twenty years. This is unquestionably owing to bestowal of increased care upon the proper support, by timbering or arching, of the roof and sides of many workings, or upon improvements in the system upon which this most important work is carried out. Cheering as these results are, it cannot be doubted that much remains to be accomplished in order to reduce the proportion of casualties from these causes to some approach towards what might be reasonably accepted as unavoidable at the present day.

Attempts have, from time to time, been made to apply iron, in one form or another, as a means of giving increased security or stability to the support applied to roof and sides in mines, and some of the more recent of such applications are said to have presented decided advantages, though, as yet, no really extensive use appears to have been made of iron supports or frames, at any rate in this country. There is no doubt that unremitting, careful inspection, and the continual devotion of skilled labour judiciously applied, the provision and maintenance of thoroughly reliable supports, even where their necessity may be somewhat open to question, are the best safeguards against accidents due to falls. While it may be very desirable for mine owners to make special provision for the maintenance of the timbering and arching of the ways of a mine in a thoroughly efficient condition, by skilled labour specially provided for the purpose, the proper timbering of the working places will generally be in the hands of the miner himself; it is, therefore, of the highest importance that ample means should be provided, in convenient positions underground, to enable him to do this readily and thoroughly, and that every encouragement and facility should be afforded to enable him to obtain training in the operation of timbering, and to prevent him from grudging the extra time and labour necessary for carrying out the work thoroughly.

One great safeguard to the miner against accidents from falls of stone and coal would obviously be the provision of efficient illumination of the ways and working placings. It is of small avail to impress upon him the necessity for constant vigilance, so that he may escape as soon as he perceives the first signs of an impending fall, unless he has sufficient light to enable him to see distinctly, if only in his immediate vicinity. One powerful excuse for the use of naked lights, even where risk of producing explosions was known to be incurred thereby, has been sought, and even sometimes admitted, in the necessity for more light in insecure places than that furnished by the Davy, the Geordie, or the Clanny lamp ; and the argument against enforcing the general adoption of safety lamps, strongly urged by Mr. Burt and other authorities, on the occasion of the debate in the House of Commons to which I have already referred, was the miserable insufficiency of the light afforded by them, and the consequent necessary increase in the number of accidents due to causes other than explosions, and which could often be avoided if sufficient light were at hand. Among improvements of late effected by many in connection with the construction of safety lamps, has been the increase of their illuminating power; and this subject of underground illumination, which has received the special attention of the Commission, as I shall presently have occasion to point out, is, I may confidently say, ripe for very great amelioration. Such improvement cannot fail to operate beneficially in reducing the number of particular kinds of accidents grouped together as miscellaneous, which occur but too frequently during the daily routine work of a mine, especially those connected with the output of the coal, *i.e.*, its removal from the working places to the bottom of the shaft or pit.

The simple modes of underground transport of coal by manual or horse labour have now, to a very considerable extent, given place to its haulage, in large quantities at a time, along tramways, by means of wire ropes or chains actuated either by steam hauling engines placed near the pit bottom, or by compressed air engines stationed in different parts of the main roads. Some good illustrations of hauling machinery of these kinds were included in the exhibition, and members of the Society of Arts cannot fail to remember with interest that our late lamented chairman, Sir William Siemens, was the pioneer in the introduction of electric hauling arrangements for mining work.

A fruitful source of disaster connected with mines has been the descent or ascent of the men by the shafts, and many contrivances have been devised, some of which have been more or less extensively applied, for preventing accidents resulting from the overwinding of the cages in which the men and the coal are brought to the surface, or from the fracture of the rope with which these cages are worked; so-called safety hooks, or detaching hooks, being used for disconnecting the cage from the rope in the event of overwinding, while safety catches are applied to a free-falling cage in its descent down the shaft, by gripping the pit guides or cutting into them. Although the utility and real efficiency of not a few of these devices have been demonstrated by actual experience, their possible fallibility and occasional failure have engendered hesitation in their general adoption ; but they cannot fail to be important safeguards, equally perhaps with those afforded by great improvements which have been, and are, continually effected in the construction and quality of the hauling or pit ropes, of which a new form of wire rope recently exhibited by Mr. Latch afforded an interesting illustration. It need scarcely be pointed out that it is impossible to overrate the necessity for the bestowal of the highest skill and care upon the manufacture, testing, and periodical inspection of these all-important adjuncts to mining work, to which many thousands have daily, in blind confidence, to trust their lives.

The great improvements which have been effected in the steam brakes and reversing gear applied to the powerful winding-engines which, as monuments of mechanical skill, merit the careful inspection of all interested in mining industry, are most important additions to the safety appliances provided in the present day in connexion with the pit work of our mines. To these must be added the improvements made in signalling arrangements from the surface and underground, in connexion with which electricity has of late commenced to play an important part.

The great advance which has been made in the ventilation of mines during the past half century is well known to all who have paid the least attention to these matters. Not only has the ventilating furnace been greatly improved in efficiency and power; the steam jet and compressed air have received important application within the last thirty-six years, and mechanical ventilating agents of great power have come into extensive use during the past twenty-three years. In 1850, Mr. Kenyon Blackwell, the well-known authority on mining, reported, as Commissioner to the Home Secretary, that "the liability to derangement in all machines appears to preclude their use in ventilation, in other than exceptional cases. In mines of large extent it would be difficult, perhaps impossible, to withdraw the workmen, in case of breakage, before danger ensued." But at the present time, many hundreds of fan- and other mechanical ventilators are in operation in connection with mines in this country, such as the Guibal, Waddle, Schiel, and Rammel fans—some of which are of stupendous dimensions—and the Nixon, Cooke, Roots, and other mechanical ventilators. The volumes of air which are passed through mines in the present day would not have been dreamt of a few years ago. Thus, a current of air travelling at the rate of more than 400,000 cubic feet per minute is maintained at the South Hetton and Merton collieries by means of three furnaces. By some it is even contended that ventilation is now carried in certain mines to an extreme which may not be unattended with danger, as the tendency of powerful currents, in rushing to the point of egress, is to favour the emission of fire-damp from the surface of the coal; there are some who maintain that the forcing of air down the pit-shaft, a practice which has received some limited application, is much safer than drawing rapid air currents through the mine and up the shaft, because the pressure of air forced in would tend to check the escape of gas from the coal, and from receptacles where it may be lodging. It scarcely can admit of doubt, however, that the release and rapid removal of gas by air currents sweeping rapidly towards the upcast shafts of the pit must be comparatively more conducive to safety. The proper distribution of the air which is drawn down into the pit, and the arrangements necessary for ensuring the distribution of fresh air throughout the different roadways and workings in a mine, and its isolation from return- or foul air- currents which are passing to the upcast or exit shaft, are now carried out effectually in a large proportion of our coal mines; though here and there much still remains to be accomplished in this direction.

Although we have long been familiar with the nature of fire-damp, and with the generally-accepted explanations of its origin in coal, considerable uncertainty and consequent diversity of opinion still prevail as to the condition in which the gas is pent up in coal, and in the strata immediately associated with it. That the light carburetted hydrogen, which chiefly composes fire-damp, exists, with with its associated gases, in a more or less condensed condition, in coal, even some time after removal from the pit, and that the gradual escape of the condensed inflammable gas from coal has constituted a fruitful source of disaster to coal-laden ships, and to steam-vessels carrying a large provision of coal—such as our ships of war—are very well known facts; but there are constantly-recurring phenomena connected with the escape of gas from coal, a really satisfactory explanation of which is still wanting, although patient inquiry has long been devoted to its discovery. The distribution of gas through certain seams of coal under very considerable pressure is rendered manifest to those visiting a new drift in such a seam, by the escape of gas more or less over the entire face of the coal with a singing or hissing noise, sometimes almost deafening, as it forces its way through films of water which frequently cover the coal, or as it bubbles up through puddles on the floor. If cavities exist in the coal, or are bored into it and plugged, the gas will accumulate there so as to exercise considerable pressure, as demonstrated by some recently published experiments, instituted by one of the Royal Commissioners at the suggestion of his colleagues, in several collieries. Borings of different depths were made into the coal, and the pressure of gas which accumulated at the far end of these borings was measured by pressure gauges fixed into their openings, and found to range up to over 200 lb. upon the square inch, and in one case even up to 460 lb.; the pressures attained varied very considerably even in one and the same seam, and in borings in close proximity to each other.

In some localities, the gas issues as a jet, or so-called blower, with very considerable force, and many of these blowers furnish a continuous supply of gas under fairly uniform pressure, so that, by closing in the face of the coal with brick-and-cement-work, into which an exit pipe is fixed, the gas may be conducted in a steady stream to the surface, where it is utilised for heating and even for illuminating purposes. It often happens that these natural gas supplies, which continue for very long periods to be evolved in undiminished quantity, suddenly fall off considerably, or cease altogether. Many explanations have been offered of the existence of these blowers, and of the maintenance of the gas supply, but they have remained a mystery. Their occurrence has been an interesting feature connected with coal mines, from a comparatively early period. Thus, in 1765, such considerable quantities of gas were evolved from the seams of Whitehaven and of Workington, that a copious supply was brought to the surface by pipes, and a proposal was made to light up the streets of Whitehaven by means of this gas. For many years the Wallsend colliery was noted for a copious blower, which was brought to the surface, and continued for a long period to furnish a constant supply at the rate of about 120 cubic feet per minute, and many similar examples might be quoted. Remarkable as these supplies of natural gas are, they do not bear comparison, however, with the stupendous supplies which are yielded by the petroleum districts of the Caucasus, and of the United States; an interesting account given of the latter to the Society by Professor Dewar, last May, will be fresh in the memory of the members. It may be mentioned that Mr. Andrew Carnegie, in his description of the Pittsburg oil and gas fields, mentions one well in the Murraysville district, which yields 30,000,000 cubic feet of gas in twenty-four hours. In comparison with this, the most copious gas-supplies which have been furnished by blowers from coal are quite insignificant.

The systems of ventilation now in use in coal mines, and the powerful circulation of air maintained thereby, deal effectually with the removal of gas, as it exudes from freshly-worked coal even in very fiery mines, when it passes into the main ways and the workings which are actually in use; but in old workings, recesses, or cavities, and in the so-called goaves, where the worked out space has been filled up with stone and *débris* of coal, such localities being more or less out of the reach of the regular ventilation of the colliery, the gas may lurk and lodge, and may at any time constitute a source of great danger, if special means are not adopted to favour its removal; and, under any circumstances, even with the most efficient and searching ventilating arrangements, the almost unavoidable existence of some accumulations here and there in mines where fire-damp is prevalent, renders absolute freedom of the air in the mine from fire-damp practically unattainable in such cases, although the amount diffused through the air may seldom, under ordinary conditions, approach, even distantly, to the minimum proportion which, *per se*, might constitute a source of danger.

It is now generally admitted that variations of atmospheric pressure influence the tendency of fire-damp to escape from goaves or old workings in a mine where accumulations are liable to exist, and that, when a reduction of pressure suddenly sets in, such an escape may take place even to some considerable extent before the barometer indicates the depression. Some even maintain that the emission of gas from the face of coal which is being worked is considerably promoted by such alterations of pressure. Some years ago Messrs. Galloway and R. H. Scott published a series of interesting observations which indicated a connection between the occurrence of meteorogical changes and of colliery explosions; but, although there are many undoubted instances of explosions having occurred during sudden and very considerable depressions of the barometer, different observers in this and other countries are by no means in accord as to the extent to which, in a properly-ventilated mine, the existence of fire-damp in the air is influenced by barometric changes. A fortnight ago, the *Times* correspondent in Vienna directed attention to experimental observations which are being carried on systematically at some collieries of the Arch-Duke Charles at Karwin, in Silesia, with a view to investigate this question. A report has been recently issued on the first series of these experiments, but while its authors consider themselves already justified in the conclusion, that the proportion of fire-damp in the air of a mine generally increases with a diminution of atmospheric pressure, and *vice versa*, and that the increase or diminution in the emission of gas is rapid in proportion to the rapidity and extent of the atmospheric change, the actual observations given include many conflicting points. The report dwells on the fact, as a forcible illustration of the connection between explosions and barometric expressions, that in the case of four extensive explosions which occurred during the past year, including that at Clifton-hill colliery in June last, the catastrophe took place during a rapid and considerable fall of the barometer. In the House of Commons debate of 1878, to which I have more than once referred, Mr. Cowen suggested that warnings of approaching depressions should be telegraphed to collieries from the Meteorological Office, and the same suggestion has been made in other quarters; but opinions differ greatly as to the wisdom of such a course. There can, however, be no doubt of the importance of local meteorological observations, systematically carried out, and of their receiving constant attention in connection with the ventilation of the mines and with regulations respecting the firing of shots.

There are some mines so free from fire-damp that naked lights, in the form of candles or oil lamps, may be used therein with perfect safety as illuminating agents, and others where the occurrence of fire-damp being confined to some few localities, the use of safety lamps need apparently be only insisted upon in certain parts of the workings. There can be no doubt, on the other hand, that the adoption of even the most perfect ventilation cannot secure such absolute safety as to render the use of naked lights warrantable where seams are worked in which fire-damp exists in any abundance, because danger may there arise at any time, from some accidental stoppage or partial failure of the ventilating arrangements, from the effect of a reduction of atmospheric pressure in promoting the escape of gas from lurking places, or from a liability to the sudden emission of gas in considerable quantity from coal, to which reference will presently be made. The very poor light furnished by the forms of safety lamp still chiefly in use, and the consequent increase in the difficulties of working and in the risk to which the miner is exposed from sudden falls of coal or stone, have afforded very strong temptation to the men to have recourse to naked lights, and to the managers of mines to regard such proceeding with indulgence, even where its danger is well recognised. The strongest incentives have, therefore, existed to the application of inventive and constructive ability, either to the improvement of the light furnished by existing forms of safety lamps, or to the production of new forms of lamps presenting decided superiority over them in light-giving power.

It is, however, not only in this direction that the miners' lamps have needed and received improvement; the poor light furnished by the older forms of lamps in a quiet atmosphere becomes even much worse when they are exposed to such currents as are now met with in properly ventilated mines; in order, therefore, to afford that advantage over naked lights from the simple point of view of efficiency for working purposes, which shall tend to secure its preference over these, the lamps should burn brightly and steadily even in strong currents of air. Lastly, though first in order of importance, the lamp should be unable, under any circumstances at all likely to arise in coal mines, to ignite an inflammable or explosive mixture of fire-damp and air, even when this is passing at the highest velocities which can occur in any part of a mine.

The importance of determining how far modifications of existing lamps, or new kinds brought forward from time to time, fulfil the latter condition, has led individuals specially interested in the subject, and associations of mining engineers, for many years past, to submit lamps to comparative experimental tests; and the first branch of inquiry which was taken up by the Royal Commission, and which has been steadily pursued by the members up to a quite recent date, was the systematic comparison of the behaviour of different lamps in currents of explosive mixtures of gas and air, travelling at different and accurately-determined velocities. More than 200 different lamps, partly received from various manufacturers and inventors in this country, and partly from France, Belgium, and Germany, have been submitted to tests in explosive atmospheres, under variously modified conditions, representing, as far as possible, every variety of circumstances under which the lamp might be employed in a mine. As the experiments proceeded, and the results of tests applied to particular lamps became known to the makers, modifications in construction were introduced by them and by others, or new arrangements devised, and even up to the present day the Commission have continued to receive new lamps, with urgent requests that they should be included in the trials, the difficulty of bringing the inquiry to a termination having thereby been much enhanced. The investigation has not only dealt with the question of the safety of the lamps, but has also included a careful determination of the amount of light furnished, and of the burning qualities of all the more promising lamps, as well as an examination into the practical merits of the lamps, in regard to construction, weight, and handiness, it being of high importance that a miner's lamp should be simple, handy, and easily taken to pieces and put together, with the certainty that all parts are properly fitted, so as to secure safety, and that the lamp, when once lighted, cannot be readily opened. Collateral experiments have been made upon the relative merits in point of safety and efficiency, of different illuminating agents susceptible of employment in safety lamps. The experiments have beeen carried out by the Commission, partly at particular collieries in South Wales and Lancashire, where natural blowers of fire-damp, which are piped to the surface, furnished the supplies of gas with which the tests were made;—and partly at Woolwich Arsenal, where special facilities were furnished for accurate and extensive experiment.

The results of these extensive investigations will now very shortly be in the hands of the public, and I must not presume to do more than indicate their general nature.

Until within a comparatively recent period, only three types of lamp were in extensive use in this country—the original safety lamps which the miners owe to the genius of Davy and of Stephenson, and a lamp not long afterwards devised by Dr. Clanny. When the safety lamp was first invented, the ventilating currents in mines were very moderate, seldom attaining a velocity of even 5 feet per second in the principal roads or air-ways, while in the working places themselves the currents were very slight. The Davy, Stephenson, and Clanny lamps were fairly safe under these conditions in the presence of fire-damp. But at the present time the air currents in the main roadways of mines often travel at a rate of 20 to 25 feet per second, and at the working places their velocity ranges from 5 to 15 feet per second. Moreover, it is even possible that under special conditions, which may obtain in particular parts of the mine, current velocities of 30 to 35 feet may be met with. Under conditions such as these, the Davy and Clanny lamps cease to afford any security, and it has been demonstrated by the experiments of the Commission that even the Stephenson lamp, which is generally extinguished by an atmosphere highly charged with fire-damp, may bring about an explosion in currents of fire-damp and air. These facts had already been indicated by the results of previous experiments when the Commissioners commenced their work, but their own investigations so clearly established the great danger of relying upon the Davy and Clanny lamps, and the facts already known on the subject appeared to have received so little attention on the part of managers of mines (great confidence in the safety of those lamps having even been expressed by experienced witnesses), that the Commissioners considered it their imperative duty to direct the attention of the Home Secretary to the fact "that the employment of the ordinary Davy lamp, without a shield of metal or of glass, in an explosive mixture, when the air currents exceed 6 feet a second, is attended with risk of accident almost amounting to certainty," and that "the Clanny lamp, when tested in a similar current, has proved to be scarcely, if at all, less dangerous." They hoped that the most prominent publication would be at once officially given to this warning. After some delay, a circular embodying the substance of it was issued, but without any indication that it bore the authority of the Royal Commission. This action was taken as far back as December, 1880 (they having been appointed early in 1879), yet the Davy and Clanny lamps have continued in use in mines where the elements of danger insisted upon by the Commissioners exist.

The Davy lamp had, some years back, been rendered much less dangerous when exposed to strong air currents by the addition of a metal shield partially surrounding the gauze cylinder, or by the provision of an external glass cylinder extending up the gauze to various distances. The latter modification, known as the Jack lamp, if properly carried out, proved to be the most efficient safeguard of the two; a much more important protection has, however, been comparatively recently afforded to the Davy lamp by enclosing it in a case, which protects it to a great extent from the action of currents, but which, at the same time, even when constructed with glass on all sides, considerably diminishes the already very meagre light afforded by this lamp.

A lamp of Belgian origin, termed the Mueseler, and which has for many years past been officially adopted for use in the Belgian mines, presents important advantages over the lamps already referred to. These were recognised by the experimental committees of the leading Institutions of Mining Engineers before the appointment of the Royal Commission, and the lamp was then being introduced into some collieries, an action which has since then extended considerably. Some experiments and certain results of practical experience had, however, already tended to throw some doubt upon the wisdom of placing absolute reliance in the safety of this lamp, especially when the precise details of its construction, as worked out in Belgium, were more more or less departed from by English makers. The results of the Commission's experiments confirmed the doubts which had been raised by experiments of the Midland Institute respecting the absolute safety of the Mueseler lamp, even when carefully constructed as regards the proportions of its component parts, and demonstrated that, under special circumstances, it might cause an explosion when exposed to a current of fire-damp mixture having a velocity of from six to ten feet per second. Under corresponding conditions, and even in currents of much higher velocities, the cased Davy lamp was found to be perfectly safe, and the establishment of this important fact has led to the adaptation of cases in various ways to the old types of safety lamps, many so-called new safety lamps consisting, in fact, of the Davy or Clanny protected, by inclosure in various ways, from the direct action of the current.

Protracted as have been the investigations which the Commissioners have carried out with safety lamps, their publication will, I venture to affirm, convince even those who, because they have not cared to inform themselves of the character and extent of work which was being done, have thought it right and just to publicly reproach the Commission with dilatoriness, that the curtailment of these researches would only have been detrimental to the conclusive, and therefore practically important, nature of the results arrived at. For these have not only led to decisive conclusions regarding the defects of the best known and most extensively used types of lamps, and the degree of safety and other merits of a large variety of modifications of them, as well as of new forms of lamps, but they will also enable the Commissioners to indicate with confidence several lamps which combine a great degree of safety with other important merits, and to specify a few among these which, while ranking highest in point of safety, and leaving very little to be desired in this respect, combine with this first essential the important adjuncts of simplicity of construction and fair illuminating power. It will, moreover, be possible to indicate some directions in which even these lamps are susceptible of improvement. It, therefore, only remains to be hoped that the results of the labour which the Commissioners have devoted to this branch of their inquiry will be accepted with the confidence they merit, and will be speedily utilised both by those who are responsible for the management of mines and by those who control the actions of the miner.

When the Commission's investigation of the relative merits of different safety lamps were already considerably advanced, Mr. Ellis Lever publicly offered a premium of £500 for a miners' safety lamp, either a perfectly self-contained electric lamp, or other lamp, which, while being of convenient size for carrying about, would continue to give a useful amount of light for not less than twelve hours, *and which would "not cause an explosion of gas under any circumstances at all likely to represent conditions which may occur in actual practice."* It was proposed that the judges to whom lamps submitted for competition were to be referred should include three scientists, nominated respectively by Mr. Lever, by the Royal Society, and by the Society of Arts. No less than 108 different lamps were sent in, and it need scarcely be said that the determination whether any among them fulfilled the prescribed conditions involved a very extensive series of experiments. The adjudicators appointed included two members of the Commission, who cheerfully consented to take upon themselves this very considerable addition to the voluntary labours already being carried on by them in the interests of the miners.

In arranging for and carrying out the tests of these lamps, the adjudicators had the great advantage of the experience gained by the Commission as to the nature of tests best adapted to elicit information regarding the good or bad features of a lamp, and as to the performances of the different types or modifications of lamps already known.

Only four electric lamps were submitted, and these altogether failed in fulfilling any one of the conditions laid down, excepting that of being self-contained lamps. As the tests of the various other lamps progressed in severity, the number of promising ones was rapidly reduced, and, eventually, not one lamp was found completely to fulfil the whole of the conditions under which the premium was offered, although there were several which ranked very high as regards safety and efficiency; foremost among these being the lamp of M. Marsaut (with three gauzes) and that of Mr. N. Morgan, of Pontypridd. To the constructors of these lamps gold medals have been awarded at the Inventions Exhibition, and it will be found that they rank among the lamps which the Commissioners are able to speak most highly of. But the premium which Mr. Lever placed at the disposal of the adjudicators reverted to him, and those who have great experience of the behaviour of safety lamps of the various well-known and recently developed types could scarcely have anticipated a different result, in face of the conditions laid down. Mr. Lever has, since then, again offered a similar premium, this time for "the invention or discovery of an economical, efficient and safe substitute for gunpowder and other dangerous explosives used in the getting of coal." The Council of the Society of Arts could not see their way to attempt to comply with the suggestions of Mr. Lever that they should award this premium or appoint adjudicators for that purpose. Apart from the circumstance that there would be much less probability of the owner of the money being called upon to pay the premium, than in the case of the lamp competition, the Council could not have presumed even to suggest the great sacrifice of time in the performance of the very laborious and exhaustive experiments indispensable in this case, to such as would be really competent to perform the work of adjudication, which Mr. Lever appears to think at least as lightly of as of the offer of these prizes. It borders upon the amusing to observe in the article by the Manchester correspondent of the *Times*, to which such prominence was given on the 27th of last June, how the writer heralds offers of subscriptions and of premiums as illustrating the way in which his hero "gallantly attacks the problem (of accidents in mines) at all points," while he has no encouraging word for the men of science whose disinterested devotion to very arduous work, for which their sole probable recognition would be hostile criticism, or worse, can alone give any point to the "gallant attacks" of philanthropists like Mr. Ellis Lever.

The possibility of applying the electric light to the illumination of coal-mine workings was one of the most prominent of the subjects which first suggested themselves to the Royal Commissioners as demanding careful study. The superficial observer, in noting the real progress made during the last few years in the facility and success with which the electric light has been utilised equally upon a large scale, for purposes of display or for the lighting up of large areas and buildings, upon the comparatively small scale needed for illumination of small dwelling-houses and offices, and upon the very minute scale, as in connection with surgical requirements, might have been pardonably led to the conclusion that there existed no very great difficulties in the way of at once presenting the miner with an electric light in almost as portable a form as a safety lamp, incomparably safer than the best of these, and capable of affording him a much superior light for the entire duration of his longest working hours underground. A little inquiry into the subject demonstrated to the Royal Commission that such a conclusion would be at least very premature, and that, although the subject was one most worthy of patient pursuit, the attainment of really useful results was beset with formidable difficulties. It is one thing to announce in oracular fashion, as the *Times* did, in a leading article last June, "that collieries ought to be lighted in a way to dispense with safety lamps," "that electricity is the one illuminating medium which can supply the light which miners want, without the flame which endangers them." It is quite another thing to apply the electric light with safety, even along main roadways, in mines in which fire-damp is prevalent. The writer of those lines would have been less confident in his assertions had he sought sufficient information to teach him that the fracture of a glow-lamp, or the rupture of a conducting-wire, in a mine, might be as much fraught with danger as the injury of a safety lamp or the lighting of a pipe. Had he, moreover, but learned by simple inquiry what progress had been made by patient workers, at the time he was inspired thus to write, towards setting aside those sources of danger, and providing the miner with a portable and efficient self-contained lamp, he would certainly have hesitated to assert that "no proper zeal has been brought to bear upon the conquest of difficulties" in the application of electric lighting in mines, or to sneer at "the scientific brains, whom the public may encourage, though it cannot compel, to exert themselves as keenly for the illumination of a murky, dirty coal-pit, as in the transformation of a plot of ground in South Kensington into fairyland."

The Royal Commissioners' report will deal with attempts which have been made in several of the mining districts to apply electricity to underground illumination; so far as distribution of the light in main roads is concerned, no great progress has been made, though there is now no reason why glow-lamps, protected after the manner in use at our Government Gunpowder Works (as shown at the recent Exhibition), should not be distributed to considerable distances along such portions of a mine, the conducting wires being placed in secure positions and effectually protected. At Risca Colliery, in Monmouthshire, at Harris's Navigation Colliery, near Pontypridd, and at Earnock Colliery, at Hamilton, N.B., a commencement has already been made in this direction with satisfactory results. If, however, the miner is to have an electric lamp for lighting up drifts and working places, it must be supplied to him in a self-contained and really portable form, with absolute protection or isolation of the glow-lamp from the surrounding atmosphere, and with a store of power sufficient to maintain an efficient light for ten or twelve hours.

The considerable improvements which have of late been made in secondary batteries, or accumulators, and the advance which has also been made in the construction of constant primary batteries, have led to very important progress toward the attainment of these essentials since lamps were submitted for competition for the Lever premium about two years ago. Mr. J. Wilson Swan, universally celebrated for his achievements in the matter of glow-lamps, who was encouraged by the Commission in the early days of its existence to give his attention to the adaptation of the glow-lamp to the miner's use, and has since patiently pursued the subject, has not long since succeeded in producing a lamp which, with its small storage battery, weighs little more than 8 lb., and which will furnish a light equal to from two to four times that given by the better forms of safety lamp for a duration of ten or twelve hours. The beautiful miniature glow-lamp which furnishes the light is perfectly shut out from the air and protected from accidental fracture, and the battery will bear swinging about without detriment. Mr. Swan is sanguine that he will ere long be able to effect an important reduction in the weight and bulk of the lamp, and he is not less hopeful of elaborating a primary battery similar in portability and light-giving power, the substitution of which, if successful, for the accumulator would have the advantage of dispensing with the necessity for providing dynamo-electric machines and power for charging the storage cells, though the great advantages presented by electric illumination, especially with arc lamps, of the surface establishments of a colliery, will probably lead ere long to the extensive employment of dynamo machines for such purposes. Other workers besides Mr. Swan, such as Mr. Coad and M. Trouvé, have been applying small primary batteries to the production of miners' lamps with some promise of success, although as yet the results furnished do not bear comparison with those obtained by Mr. Swan with the storage battery. Those who have spent any length of time under ground, especially in the very low workings which abound in coal mines, and at the high temperature which often prevails in the workings of deep mines, will have experienced the fact that any incumbrance may sometimes become very burdensome, and can well understand, therefore, that the weight and size of even the lightest form of battery with which an efficient light could be maintained for a sufficient length of time, may prove grave obstacles to its extensive employment. Moreover, as the electric light can afford no indication of the condition of the atmosphere in a mine-working, its employment may not, even under the most favourable conditions, altogether allow of the safety lamp being dispensed with. But even if used only as an auxiliary means of illumination in working places, such lights as those which Swan and others will supply, will prove very valuable. A similar lamp, of somewhat larger size and comparatively much greater illuminating power, may also prove invaluable for exploring purposes, especially after accidents due to outbursts of gas, when the best safety lamps may be of little use, even if they continue to burn. Such electric lamps must indeed become formidable competitors of the Fleuss lamp (included in the recent Exhibition), which has, in conjunction with the portable apparatus for the supply of respirable air to explorers, already performed important service in rendering access to mine-workings possible where an ordinary lamp could not burn, and where the atmosphere was too foul to support life for any time.

The sudden escape into a mine-working of a very large volume of fire-damp, the accumulating pressure of which has at length overcome the resistance opposed to it, either by the coal or by the stone which form the floor or the roof of the mine, and the outrush of which is sometimes accompanied by the ejection of very large quantities of disintegrated mineral, constitutes the most formidable danger connected with this associate of coal, because little or no warning is received of its occurrence, and because the volume of gas suddenly liberated is often so considerable that the most powerful ventilating currents are for a time inoperative, while their very action may be to distribute gas rapidly in the form of an explosive mixture with air to distant parts of the mine-workings. In the earlier records of these "sudden outbursts" of gas, when the ventilating currents in a mine were comparatively very feeble, men were not unfrequently asphyxiated by the gas which for a time remained but little diluted with air in the neighbourhood of the outburst; on the other hand, the considerable time which, under these circumstances, was required to bring about the production of an explosive mixture has, in some cases, facilitated the escape from critical surroundings of those who have been in the neighbourhood of the outburst. It appears that, as the depth of coal-mines has increased both in this country and in Belgium, these violent emissions of gas have increased in frequency. The volume of gas suddenly set free varies very greatly; sometimes it is so considerable that, even with very powerful ventilation, the workings have not been restored to a safe condition for work, in regard to comparative freedom from fire-damp, until several days after the occurrence of the outburst. One of the most formidable outbursts of gas upon record is that which occurred in April, 1875, in the district of Mons, at L'Aggrapp, near Frameries, which caused the death of twenty-one persons. An overwhelming volume of pent-up gas became suddenly liberated; passing up the downcast shaft it was fired at the engine-house, and burned as a column of flame 120 feet high, of the diameter of the shaft. The eruption continued for three hours in almost undiminished extent.

The Royal Commission has paid very considerable attention to these remarkable occurrences, with the view of endeavouring to throw some light upon their nature and origin, and it is not impossible that the results of their study of the subject may, when published, at any rate remove some little of the absolutely mysterious character which has hitherto been their attribute.

That these sudden outbursts of gas have been intimately connected with some of the most appalling disasters which have occurred in coal mines appears beyond question, and there is equally little room for doubt that the firing of shots, or use of gunpowder for blasting coal or stone in mines, has been, in many cases, intimately connected with those disasters. The concussion and local disturbance, or breaking up of the coal or stone, produced when a shot is fired, may have the effect of releasing a large volume of gas pent up in the immediate vicinity of the shot, or of determining the sudden outburst of a quantity of gas accumulated under great pressure in the neighbourhood, and the firing of a shot is but rarely quite unaccompanied by the production of flame, or the projection of incandescent particles, whereby gas may become inflamed at the moment of its liberation. This result could in itself scarcely ever be likely to be productive of any serious destructive effects, because the gas would be inflamed before it had time to become mixed with more than a small quantity of air, and certainly not with the comparatively large volume necessary to produce *explosive*, and consequently destructive, effects If, however, the gas escapes ignition by the flame of the shot which has released it, or if it becomes liberated at too great a distance from the shot to be reached by any flame that is developed, it will rapidly mix with the air in the workings, filling these more or less extensively with an explosive gas mixture which, as shots are rarely fired singly, is liable to be exploded by the firing of the next shot, the fuse of which is already burning.

The production of a sudden outburst of gas, or the liberation of gas by the violent breaking up of coal or stone, is, however, not essential to the production of disastrous results by the firing of powder or other explosives in coal mines. Indeed, the opinion has been entertained by those who are inclined primarily to ascribe the occurrence of these disasters to neglect or supineness on the part of colliery proprietors or managers, that coal mine explosions are too readily assumed to have been brought about by a sudden outburst of gas, which affords a comparatively easy and apparently satisfactory explanation when others fail, and one which may have a tendency to arrest sufficiently searching inquiry.

The flame or fire projected by the firing of a powder-shot may, without any favouring circumstances, be projected to a considerable distance beyond the face of the coal or stone in which it is fired, if, as is frequently the case, the force developed is insufficient to accomplish the fracture of the bore-hole in which the charge of explosive is confined, and the highly heated products of the explosion are entirely projected from the hole, as if the shot had been fired from a gun. Thus, in some experiments made on this head by the Commissioners, in military mine galleries corresponding in dimensions to coal mine workings, and where no conditions prevailed which were calculated to favour the extension of flame from a shot, charges of 1½lb. of gunpowder, fired so as to ensure the production of a so-called blown-out shot, extended to distances of about 20 ft., in a capacious gallery representing the main road of a mine, and to distances of 30 to 35 ft. in galleries of much smaller dimensions, similar to mine-workings. In these experiments the powder charges were, in some cases, not tamped at all, in others they were tamped with clay. It is by no means an uncommon practice in coal mines to employ the small *débris* of coal, which is ready to hand in the working places, as the tamping material; and it has been recently demonstrated, in the course of a series of valuable experiments made by the Prussian Mines Commission in the Saarbrücken district, that the volume of flame projected by a blown-out powder-shot is very greatly increased when the shot-hole has been thus tamped. In an experimental gallery, intermediate in size between the large and small mine galleries used in the Royal Commission's experiments at Chatham with blown-out shots, the charge, about 1 lb. of powder tamped with clay, projected flame to a distance of about 13 ft., in good accordance with the Chatham results, while corresponding charges of powder, tamped with coal dust, and fired under the same conditions, projected flame to about 60 ft. It is evident that the flame from a blown-out shot, even where coal-dust has not been used for tamping, may be projected to such a distance as to reach to the goaves of old working places or cavities where a fire-damp-and-air mixture may be lurking, which has escaped observation by the official or miner whose duty it is to see that the surroundings are free from fire-damp before shots are fired. This is, however, by no means the only, or even the most prominent, danger which may attend the occurrence of a blown-out shot in even the best ventilated coal-mine, quite independently of the possibility of a sudden release of a considerable volume of fire-damp during, and consequent upon, blasting. But before referring to what now appears to be well established as the chief general source of danger attending the use of explosives in coal-mines, I must touch briefly upon the means hitherto employed for searching for fire-damp, and for inspecting the workings of a mine, to ascertain that all is safe before men descend to work, or before shots are fired.

The first effect of introducing a Davy or other safety lamp into an atmosphere containing small proportions of fire-damp is to cause the flame to elongate, the extremity becoming narrow and more pointed as the proportion of fire-damp increases; when the latter approaches a proportion which produces with air an inflammable, and ultimately an explosive, mixture, a pale blue halo or cap is perceptible over the flame, and this increases with an increase in the proportion of gas, until the cage or gauze of the lamp is filled with flame. With some varieties of fire-damp, however, which are known technically as sharp gas, the gradations are not readily perceived between the first lengthening of the flame and the filling of the cage with flame, consequent upon the burning of a gas mixture which contains six per cent. or more of fire-damp.

The Davy lamp is generally preferred by the overmen, mine managers, or inspectors for gas-testing purposes; the search lamp is made of small dimensions, so as to admit of the flame being approached pretty closely to the roofs of a working, or of the lamp being inserted into cavities where fire-damp is most likely to be lurking. The flame is always reduced to small dimensions for testing purposes, so that slight alterations in size or form may be more readily detected. An experienced observer, whose eye has been trained to detect the first symptom of change in the appearance of the lamp flame consequent upon the presence of fire-damp in the air, may identify so large a quantity as two per cent. of gas in the air of a mine, but even this is doubtful, except in the case of observers who, like Mr. William Galloway, the well-known mining engineer (formerly Government Inspector of Mines), have specially trained themselves to the discovery and estimation of the proportion of small quantities of fire-damp by the detection of minute changes in the character of the safety lamp flame, and who may even, perhaps, succeed in thus detecting the presence of 1·5 per cent. of fire-damp.

It has, however, now been conclusively demonstrated to be of the greatest importance that responsible persons in coal mines should be furnished with reliable means for expediously detecting, without the exercise of any very special skill, smaller quantities of fire-damp than it is possible to identify with certainty, even by the exercise of great skill in the use of a safety lamp. Hence much interest and moment attach to the efforts which have been made from time to time by scientific men to devise sensitive and reliable fire-damp indicators. The late Mr. Ansell applied in several very ingenious ways some results of Professor Graham's classical researches on the diffusion of gases to the construction of sensitive fire-damp detectors, which, however, did not realise the sanguine expectations of the inventor and others who entered zealously into the application of these instruments, that a delicate and really reliable fire-damp detector had been found which could be expeditiously used in the mine at any moment. The same principles have since been applied, but apparently with no greater success, by several foreign inventors of so-called *Grisou metres*. Two eminent scientists well known to this Society, the late Dr. Angus Smith and Professor George Forbes, have proposed to detect and estimate the quantity of fire-damp in the air of a mine by ingenious applications of other important principles in physical science, and the acoustic indicator, lately exhibited by Mr. Blaikley, is a very pretty application of the principle utilised in a different way by Professor Forbes. Various forms of eudio-metrical apparatus have been constructed with the same object; the variations in the density of air due to the presence of different proportions of fire-damp, have been made the basis of other gas-indicating apparatus; a test-lamp has been constructed to furnish a flame, when burning alcohol, which is much more sensitive than the oil flame of an ordinary safety lamp; and an electro-photometric test apparatus has been devised by Mr. E. H. Liveing, which appears to be the most thoroughly practical form of gas-indicator shown at the recent Exhibition. This apparatus, in a very portable and convenient form, was made the subject of experiment, to determine its delicacy and accuracy, and was afterwards extensively used by a Committee (of which I was a member) appointed by the Admiralty to report on the means to be adopted for guarding against the occurence of explosions due to gas emitted from the coal stored in ships' bunkers, and was recommended for employment in H.M. ships for testing the air in the bunkers. It was found that, with very little practice, there was no difficulty whatever in detecting 0·5 per cent. of marsh-gas or fire-damp in air by means of it. The merits of the most prominent of the several gas-indicators have been made the subject of careful consideration by the Royal Commission, and there is no doubt that there is now no important practical difficulty in the way of identifying in the air of mines, without the exercise of very special skill, smaller proportions of fire-damp than can be detected by those most skilled and experienced in the use of a sensitive safety lamp for this purpose.

The importance of being able to recognise very small proportions of fire-damp in air has become specially evident, since the fact has become thoroughly established, by recent careful and comprehensive investigation, that when fire-damp is present in the atmosphere of a mine in proportions greatly below those necessary to produce a feebly explosive or even barely inflammable mixture, it may yet constitute a most formidable source of danger, by its co-operation with the dust which exists, in more or less abundance, in every mine-working.

The fact that coal-dust adds considerably to the disastrous effects of fire-damp explosions, was noticed already more than 180 years ago, and was referred to in published reports by well-known mine inspectors, such as Mr. J. Buddle, who was, during the first half century, the chief mine viewer in the Newcastle district; but Faraday and Lyell were the first to demonstrate, forty years ago, how important a part might be played by coal-dust, in aggravating and extending the destructive effects of fire-damp explosions. When investigating, for the Home Office, a serious explosion which occurred in the Haswell Colliery in 1844, they observed (and detailed in their report of 1845) many signs, quite recently described as novel observations by others, that the coal-dust was partly burned, and partly subjected to a charring or coking action, by the fire-damp explosion; that it covered the roof, floor, and sides, and the props and pillars of the working-places, with friable deposits of partly fused coke-dust, and that, when swept up by the rush of flame, and acted upon as described, it yielded quantities of inflammable gas, which added to the violence and magnitude of the explosion. The lucid account then published of the evidence that coal-dust may play an important part in the effects produced by mine-explosions possesses great interest; it covers much of the ground gone over by recent workers and writers on the subject, and affords a curious illustration of the ease with which the work of the most illustrious men may be overlooked or forgotten, even by those who should be specially interested in informing themselves of the existing state of knowledge on the subject. Several well-known French mining engineers published, many years after Faraday and Lyell's work, observations and experimental results as new which were simply confirmatory of those philosophers' original statements and conclusions; and to some extent this was also the case in still more recent publications in this country, by Galloway, and by Freire Marreco. Both these observers, of whom the latter worked in association with Mr. Morris and the North of England Institute of Mining Engineers, added, however, considerably to our knowledge of the probable behaviour of dust in mines on the occasion of explosions; and Mr. Galloway performed experiments upon a considerably larger scale than had previously been the case, which led him successively to conclusions not in harmony with each other, but which unquestionably combined to advance our knowledge considerably regarding the possible nature of the operation of coal-dust in propagating and even in developing explosions. Mr. Galloway was certainly the first to enunciate the conclusion that a small proportion of fire-damp is essential to impart to a mixture of air and coal-dust the power of propagating flame, though he afterwards abandoned this conclusion in favour of the one some time previously accepted by Marreco, to the effect that fire-damp is altogether unnecessary for the conveyance of flame, with explosive effects, by a mixture of dry coal-dust and air. Even his latest publication on the subject tends in the same direction, and emphasises his desire to "claim that no earlier author has gone the length of crediting coal-dust with the rôle of principal agent, and relegating fire-damp to a secondary position." The more recent results of other workers in this direction have, however, conclusively demonstrated that this is far too great a length to go, and that while, on the one hand, a dry, very fine, and highly inflammable coal-dust may, when raised and mixed with the air by the force of a blown-out shot, become inflamed, and may then carry flame to very considerable distances, with a rapidity and violence of action similar to that of a fire-damp explosion, the extent to which, on the other hand, flame is propagated, under corresponding conditions, by most descriptions of coal-dust, in the complete absence of fire-damp, is very limited. Consequently, fire-damp must play in the majority or cases, at least as important a part as coal-dust, in explosions which may be designated *dust explosions*, in contradistinction to those which have unquestionably been primarily occasioned by the accidental liberation or accumulation of large volumes of fire-damp in mine-workings

In a series of experiments which, after the calamitous accident in Seaham Colliery in the autumn of 1880, I was requested by the present Home Secretary to carry out with coal-dusts, and in which every possible precaution was taken to ensure accuracy in the composition and uniformity of the air-and-fire-damp mixtures used, in the dryness and fineness of the coal, and in other matters essential to the attainment of thoroughly trustworthy results, the fact, which had been indicated by the results of previous experiments, was conclusively established, that the proportion of fire-damp required to be present in the air of a mine, to bring dust readily into operation as an explosive agent, when thickly suspended in the air (as it is when raised by the force of a blown-out shot), borders upon, and is even sometimes decidedly below the smallest amount (2 per cent.) which a practised overman or mine inspector can detect by means of a Davy lamp. It was found that, with certain dusts which were very sensitive, either because of the high proportion of combustible matters they contained, or on account of physical peculiarities, the presence of 1·5 per cent. of fire-damp, and even less, sufficed to render them explosive when thickly suspended in the air. Various other points were established by this series of experiments, such as: the reciprocal influence of very small quantities of dust upon fire-damp and air mixtures, approaching, in composition, to explosive mixtures, and of very small proportions of fire-damp upon mixtures of much inflammable dust with air, in determining the occurrence of explosions; the fact that some descriptions of mine dust, comparatively very poor in combustible constituents, but possessed of particular physical characteristics, rank equal in regard to sensitiveness with other dusts comparatively rich in inflammable matter; and the fact, since corroborated by the experiments of MM. Mallard and Le Chatelier, of the French Fire-damp Commission, that an absolutely incombustible dust may determine the inflammation of mixtures of fire-damp with air in proportions insufficient to be inflammable under ordinary circumstances provided it presents physical characteristics, which impart to it properties similar to those of certain metals in a very porous condition. No positive evidence was furnished, by a large number of observations made upon the comparatively small scale of these gas and dust experiments, that even what may be called sensitive dusts would propagate flame to any considerable distance, when thickly suspended in air, in the complete absence of fire-damp, but the more extensive experiments subsequently made by the Commission, in the Military Mine Galleries at Chatham (in 1882), demonstrated not only that this was the case, but that, even with very moderate proportions of highly inflammable dust suspended in the air in which no trace of hydrocarbon gas was present, a blown-out shot, obtained with 1·5 lb. of powder, and no coal-dust tamping, produced ignitions which extended as far as the mixture of air with sufficient dust to maintain flame extended.

The important series of experiments upon a large scale, already referred to, which have been carried out by the Prussian Fire-damp Commission, at Neunkirchen, in the Saarbrücken district, in a specially constructed gallery of large dimensions, and resembling a mine gallery in its proportions, have confirmed and also considerably extended the results which have just now been alluded to. They appear to have thoroughly established the principal facts already referred to, which are so important that they may well be succintly recapitulated :—

1. The sensitiveness of dusts to explosion depends not only upon their inflammability, or the proportion of combustible matter they contain, but also upon their fineness and certain other mechanical and physical peculiarities.

2. The presence of fine coal-dust in the immediate vicinity of the working place, gives rise to more or less considerable elongation of the flame from a blown-out shot, whether small quantities of fire-damp be present in the air or not.

3. This elongation or propagation of flame by dusts is generally of limited extent, in the complete absence of fire-damp, even if deposits of the dusts extend to considerable distances beyond the seat of the shot. The use of coal-dust tamping has the effect of decidedly, though not very greatly, favouring this limited propagation of flame by dust.

4. There are, however, some descriptions of very inflammable dust which, when raised in dense clouds by the action of a blown-out shot and fired by it, will not only continue to carry the flame on, even to distances beyond the confines of the dust deposits, but will also produce explosive effects, in the complete absence of fire-damp, which resemble those furnished by some other dusts, only when there is a large admixture of fire-damp in the air.

5. All the phenomena produced by the burning of, and propagation of flame by, coal-dust, are intensified by the presence in the air of only small proportions of fire-damp, the required quantity varying with the sensitiveness or ready inflammability of the dust.

It has also been demonstrated by the German experiments that a coal-dust ignition or explosion, produced in the absence of fire-damp, with highly inflammable dust, can communicate ignition to an explosive gas mixture, existing at a very considerable distance from the point of first ignition, and *vice versâ*. It need scarcely be stated that confirmatory evidence was obtained of the fact first pointed out by Faraday and Lyell, that a fire-damp explosion may bring into operation supplementary effects of coal-dust, which add considerably to the total destructive effects of an explosion.

It appears to be well established that the considerable volume of flame and rush of gas produced by a blown-out shot is indispensable to the attainment with certainty of any of the effects of coal-dust enumerated in the foregoing. Inasmuch as blown-out shot are of very common occurrence in blasting operations, it is evident that in dusty mines there is a frequent liability to the production of a more or less extensive ignition or explosion of coal-dust, at any rate when even only very small proportions of fire-damp exist in the air of the mine; and it must be borne in mind that the failure to discover fire-damp by a careful search with a sensitive safety lamp flame, as hitherto practised, affords no security against the existence in the air of a proportion of fire-damp quite sufficient to determine, or to greatly promote, the propagation of flame by mine-dust. It will be seen, therefore, that it needs not a sudden liberation or a sudden outburst of fire-damp in considerable quantities, through temporary failure of the ventilating arrangements, or through the escape of considerable quantities of hidden fire-damp from goaves, old workings, or cavities, consequent upon sudden changes in atmospheric pressure, to cause the flame which may be projected into the air by the firing of a powder-shot, to bring about extensive explosions, or ignitions, spreading over large areas, and possibly communicating to distant accumulations ofexplosive mixtures of gas and air in old workings.

These most serious dangers, arising chiefly from the use of powder in coal-mines, have received the anxious attention of the Commissioners, who have, in the first place, considered how far it might be practicable to prescribe effectual means for removing or counteracting the elements of danger presented by the existence of dust accumulations in mines where, even with the most efficient ventilating arrangements in unerring operation, it is impossible to guard against the distribution of small proportions of fire-damp through the air. The fairly complete removal of dust, even only from the neighbourhood of the working places, presents enormous difficulties, and effectual measures for laying or otherwise dealing with the dust, so as to prevent its being disseminated to a dangerous extent through the air by the firing of shots, have yet to be discovered, though such expedients as watering the dust, and impregnating it with some material which might perhaps maintain it in a sufficiently damp condition to prevent its flying, have received much attention. Similarly, other devices, which have been tried with the object of preventing the occurrence of blown-out shots, where powder is used, have failed to furnish promising results.

The possible substitution for gunpowder of other explosives which may be applicable to the kind of work performed with it in coal-mines, has naturally received attention from mine owners and managers, and the superior merits of various explosive agents, not only in respect to efficiency, but also as regards safety, have been from time to time advocated, generally by interested persons, though they not unfrequently possessed little or no claim to consideration beyond that which lies in the possession of a new fancy trade name. A reduction in the volume of flame produced by gunpowder when used as a blasting agent has been effected by modifications in its composition, whereby the proportions of the two sources of flame, carbonic oxide and alkaline sulphide, produced by the explosion of powder, would be more or less considerably diminished; but the best result attained until recently in this direction had not materially reduced the danger of using powder, either in the presence of an explosive mixture of fire-damp and air, or in the air of a mine in which, at the time of firing a shot, coal-dust becomes thickly suspended, and in which, at the same time, some small proportion of fire-damp exists. Some promising results have, however, been quite lately attained in Germany with a special powder produced by the original maker of the now celebrated cocoa powder, the publication of which is looked for with much interest.

Of the many explosive mixtures analogous to powder in composition which have had, or are destined to enjoy, a brief existence, there is not one which, even approximately, fulfils the conditions of a safe explosive agent for coal-mines. Special forms of gun-cotton were prepared for use in coal in the early days of the improvements made in its preparation; but the large proportion of the inflammable and poisonous gas, carbonic oxide, which its explosion furnishes, prohibits its employment in this direction; even when the additional oxygen required by theory for the complete oxidation of the carbon is supplied, in the form of saltpetre or other nitrate, with which finely divided gun-cotton may be incorporated (as in the original nitrated gun-cotton, and the similar preparations, tonite and potentite), there is still no reliance to be placed in the explosion of such a preparation being unattended by flame.

Nitroglycerine contains actually more oxygen than required for the complete burning of its constituents, carbon and hydrogen, and hence its detonation in the open air is attended only by the appearance of a lightning-like flash of light. When diluted with an inert non-combustible material (such as the silicious earth *Kiesel-guhr*), whereby it is converted from the liquid form into a moist, mouldable powder, known as dynamite, its detonation raises to a high red heat the particles of mineral matter with which it is mixed, many of which are, therefore, projected in a glowing state, like a shower of sparks, if the dynamite be fired in a strong shot-hole. If, as is frequently the case in modifications of the so-called No. 1 Dynamite, some proportion of combustible or inflammable material be used, with or without oxidising agent, in conjunction with the inert absorbent, the employment of such a preparation in coal-mines must always be attended by a risk of flame being projected. Even with Nobel's blasting gelatine, the latest and most powerful explosive agent (consisting of nitroglycerine, incorporated with a small quantity of gun-cotton, the complete oxidation of which is accomplished by the excess of oxygen in the nitroglycerine), a blown-out shot may be attended by the projection of some glowing particles of the tamping used, or of particles detached from the blast-hole, and at the same time exposed to the high heat of the exploding charge.

The Commissioners have satisfied themselves by many experiments, of which a considerable proportion have been most ably carried out for them by Mr. W. Galloway, that an explosive mixture cf fire-damp (or coal gas) and air may be, and is very generally, though not invariably, exploded by the projection into it of these sparks, or incandescent particles, from a dynamite or blasting gelatine shot; they will even occasionally produce ignition, when projected into air containing only a small proportion of fire-damp, but in which coal-dust is thickly suspended. These nitroglycerine preparations are too violent and local in their action for use, in the ordinary manner, in coal; they are efficient in hard rock and stone, but they cannot be safely employed in the usual way upon work of this kind in mines where there is a possibility of the existence or liberation of fire-damp, or of the production of a dust-laden atmosphere containing a small proportion of that gas.

The outline which I have given you, I trust not in too wearying a detail, of the dangers attending the use of explosives in coal-mines, and of the very formidable—apparently unsurmountable—difficulties attending any attempts to approach immunity from the two great elements of danger naturally existing in a very large proportion of coal-mines, namely, fire-damp and dust, will probably lead you to the conclusion that there is but one effectual method of dealing with the serious question of accidents due to explosions in coal-mines, namely, that of enforcing the exclusion of the other great source of danger, by prohibiting the use of explosives.

In the House of Commons Debate of June, 1878, to which I referred some time since, Mr. Macdonald acknowledged that the provisions of the Coal Mines Regulation Act of 1872, for prevention of accidents through the use of gunpowder in fiery mines, had been productive of great good. A general rule, included in that Act, prescribes that gunpowder shall not be used in a mine during three months after any inflammable gas has been fired in it, unless a competent person, whose duty it is to examine the place where the powder is proposed to be used and the places contiguous thereto, finds it safe to do so, and accordingly allows the shot to be fired. It also directs that no shot shall be fired except by, or under the direction of, a competent person appointed for the purpose; that if, on examination, inflammable gas is found in such quantities as to show a blue cap on the flame of a safety lamp, powder shall only be used in stone-drifts, stone-work, or shaft-sinking, when particular, well-defined conditious in the ventilation of those places are fulfilled, and only when the persons ordinarily employed in the mine are out of it, or of that part where the powder is to be used. Mr. Macdonald insisted, however, that these regulations were insufficient to guard against fire-damp explosions, and referred, in illustration, to the fact that the firing of the shot itself might liberate a large quantity of gas which no previous inspection would discover. He urged in the strongest terms that, until blasting in any fiery mine were absolutely prohibited, there must be a continual recurrence of terrible disasters; and, in the debate which followed, there was a general consensus of of opinion among the speakers most competent, from personal experience, to express a decided view on the subject (such as Mr. Burt, Sir G. Elliot, and the late Mr. Knowles), that blasting should be prohibited in fiery mines. It was pointed out by several speakers that, while the use of any light except a locked safety lamp, in a place where there was likely to be an accumulation of explosive gas, was prohibited by the Act of 1872, the firing of shots, whereby a large volume of flame might be projected into the working place, was permissable under conditions which might lead to disastrous explosions. It was admitted that the cost of working coal would be much increased by the enforcement of the suggested prohibition, and, in the evidence taken two years afterwards by the Royal Commission, it was maintained by the majority of the witnesses who were competent to speak from practical knowledge and experience of the state of things existing in districts where powder was largely used, that the abolition of shot firing in the working of coal must be attended by very formidable difficulties, and must, in fact, cause the closing of many pits. The greater number of H.M. Inspectors of Mines held the view that, if the general rule of the Act which relates to blasting is stringently carried out, no additional precautions are necessary. Some few, on the other hand, considered that shot firing should not be allowed in any mines where fire-damp is liable to exist, unless all the workmen are out of the mine, excepting those who have actually to fire the shots.

I have shown that it is now established, beyond reasonable doubt, that even the comparatively very small amount of fire-damp which may, at any rate occasionally, pervade the air in portions of mines where thorough ventilation is most effectually provided for—an amount quite insufficient in itself to constitute a source of danger, and not even detectable by the ordinary method of inspection—may determine the production of a disastrous explosion, if, under these circumstances, a blown-out shot occurs where an accumulation of dust exists; and that it is even possible, in the complete absence of fire-damp, for a blown-out shot to give rise to an explosion in a very dusty working or mine, where the coal is of a specially inflammable and sensitive character. Such being the case, the fact cannot be ignored that last year's decision of the late Home Secretary, which raised consternation in many mining districts, to prohibit the firing of shots in any colliery within a period of three months after the existence of gas had been there reported, while the workmen were in any part of the mine, is far from affording the contemplated protection against disaster resulting from the use of explosives *in the ordinary manner*, inasmuch as the conditions favourable to extensive explosions may exist in mines in which the search for fire-damp, carried out as hitherto, may have failed, for very long periods, to afford any indication of its existence.

These considerations undoubtedly favour the conclusion that the suggestion so strongly supported in the debate of 1878, that the use of powder should be prohibited in fiery mines, disastrous as its adoption might be to the coal-mining industry in many parts of the country, falls very short of the necessities demanded by the safety of those employed underground, which could only be thoroughly met by prohibiting blasting in all mines where dust is produced in any abundance at the working places (which would amount to almost complete prohibition), or, at any rate, in all mines where, by means of special gas-indicators, fire-damp to the extent of 1·5 per cent. is detected in the air of the mine, and in goaves or other lurking places within a given distance from the place where a shot is to be fired.

This most grave aspect of the question, which would have afforded scope for even more highly sensational writing than that which appeared in some public prints a few months ago, had it been under the cognisance of such editorial pens as that which counselled Sir Richard Cross to "shake the Royal Commissioners out of their long but premature repose," has received the anxious attention of these Commissioners. They have considered it their duty not to relinquish their work till they had practically investigated, as far as in their power, any measure or suggestion appearing to afford promise of aid in furnishing definite replies to the following important questions:—

a. Whether sufficiently efficient substitutes for explosives in the working of coal-mines exist, to warrant the assertion that their abolition need not interfere very materially with the reasonably profitable working of collieries;

b. Whether, therefore, it is practicable to limit the use of explosives strictly to localities where the absence of every possible risk of explosion can be demonstrated to the satisfaction of the official authorities; or

c. Whether any modifications in the ordinary method of using explosives can be so confidently relied upon to guard against, or overcome, certain dangers attendant upon blasting operations in collieries, that it may be practicable to clearly define and lay down conditions which will ensure the safe use of explosives, either generally, or in all but special cases, which can be precisely defined.

The improvements, which have of late years been effected in mechanical appliances for bringing down coal, or for the taking down of stone overlying thin seams, or in the driving of headings or crossways, have been referred to by me in the early part of this discourse; the Commissioners have made themselves practically acquainted with the working of the most prominent of these, and the power and efficiency of some of them appear to warrant the sanguine expectation that compressed air and even manual power may be, at no distant day, brought to bear so advantageously, and with such comparative expedition and economy, upon the work to be done in stone or hard coal, in mines where fire-damp occurs, as to render it no hardship to dispense with the use of explosives in some of the descriptions of work where at present they are considered indispensable.

The considerable and very rapid increase in volume which freshly-burned quick lime sustains when slaked, led, many years ago, to attempts to apply it to the bringing down of coal; but the idea did not assume a really practical form until Messrs. Sebastian Smith and Moore worked out a simple method of applying the lime so as to ensure the effective operation of the disruptive force which it is capable of exerting, and to utilise the considerable heat, developed by the energetic chemical union of the lime with water, in the rapid generation and superheating of steam in somewhat considerable quantity, thus supplementing, in an important manner, the force exerted by the expansion of the lime. The public has been made familiar, in last year's and this year's Exhibitions, with the general nature of Messrs. Smith and Moore's lime cartridges, and of the system of using them; briefly, the freshly burned and finely ground lime is compressed into the form of very compact cylinders, and the introduction into a bore-hole of a simple appliance, together with these lime cartridges (the hole being charged with them, and tamped in the ordinary manner), enables the operator to accomplish expeditiously the simultaneous application of water throughout the entire length of the charge. Several holes, at suitable distances from each other in the face of the coal, are charged before the watering is taken in hand; they are then set into operation in rapid succession, and after the lapse of several minutes their combined action brings down the coal in large masses. The Commissioners witnessed the performances of these lime cartridges at Shipley Collieries, in Derbyshire, soon after their successful elaboration, and the results of subsequent inquiries and experiments connected with this subject have convinced them that, for coal getting, the lime process can be, to a large extent, substituted for powder, and that its employment secures comparative immunity from danger, and is unattended by any important practical difficulties.

In spite of the obstacles, which have always to be surmounted by any complete departure from old practices and traditions, the lime system has gradually received more or less extensive trial in many of our mining districts, and also on the Continent, and has already taken firm root in some parts of Staffordshire, Yorkshire, and Derbyshire, having proved itself capable of competing, and even advantageously in point of economy, with powder in many descriptions of coal, which are so worked as to allow of several charges being applied at one time.

It is not contended by the elaborators of the lime-cartridge system that it affords the means of dispensing with the use of explosives, or of specially powerful mechanical appliances, in the removal of stone, or even in some hard coal or in connection with certain methods of working underground; but it is now beyond doubt that in many of the collieries, where the prevalence of fire-damp renders the use of the safety-lamp imperative, the replacement of shot-firing by the use of lime-cartridges, while unattended by any increase in the cost of getting the coal, would reduce the risk of explosions to those arising from carelessness on the part of the men, or from what should now become the very remote contingency of the use of unsafe or defective lamps.

The idea has been entertained that, by surrounding or covering the charge of powder in a shot-hole with some material which evolves vapour of water, or carbonic acid, when exposed to sufficient heat, these would be liberated by the firing of the shot in sufficient quantity and with sufficient rapidity to extinguish flame and sparks projected by it. Prescriptions, based upon assumed chemical reactions, for the preparation of *extinguishing* powders, have been made the subject of patents, but the authors of these suggestions have failed to realise the fact that the exposure of such substances to heat on the firing of a shot would be almost instantaneous, and would therefore leave, at any rate, the greater proportion practically unaltered. It was suggested by me to the Commissioners that possibly the sudden liberation of carbonic acid, confined in the liquefied state, in a suitable case, and placed either over or under the charge in a shot-hole. might prove effective in extinguishing flame and sparks, and a number of experiments have been made in this direction, with considerable though not complete success.

Some time before the appointment of the Commission, Dr. McNab put into practical execution the idea of using water tamping, in the form of a long cylinder filled with the liquid and placed over the powder charge, with the two-fold object of extinguishing the projected flame and sparks, and of diminishing, by dispersion of the water in the immediate vicinity of the shot, the persistence of the powder smoke, which is a source of much inconvenience and loss of time, if not of danger to the miner.

Practical experience appears to have demonstrated that decided economy in time does result from the more rapid clearing of the air from smoke when the water tamping is used in firing shots in drifts, but many careful experiments conducted by the Commission, and on their behalf by Mr. Galloway under my instructions, showed that no reliance could be placed upon the extinguishing power of water, applied in conjunction with gunpowder in the way originally suggested by Dr. McNab. It has been demonstrated, in fact, that, in the majority of cases, a blown-out powder shot, in the preparation of which water-tamping has been employed, will fire an explosive mixture of fire-damp and air into which the shot-hole debouches. On the other hand, the raising of coal-dust by the firing of a blown-out powder shot in air which contains a proportion of fire-damp below that required to produce an explosive mixture, may not be attended by the firing of the mixture (which, as already pointed out, it certainly would be, if powder were employed in the ordinary manner) provided the water-tamping be very considerable in proportion to the powder charge used.

When the Royal Commissioners commenced their labours, in 1879, I suggested to them a plan by which possibly the more violent explosives of the dynamite class might be safely and efficiently applied to the getting of coal. This plan was based upon the principle first developed by me in 1873, in the course of my researches on detonating agents which were then communicated to the Royal Society, of distributing the force developed by the detonation of small charges over a considerable area, through the agency of a column of water, *within* which the detonated charge was confined. It appeared to me that this principle, which has since received important applications in connection with military service, was applicable to effect a modification of the so-called local, or shattering action, which renders a violent explosive like dynamite inapplicable to coal getting, when fired in a shot-hole loaded in the ordinary manner, and that the disruptive effects might thus be rendered similar to those of gun-powder, while, at the same time, the quenching of the sparks projected by firing a dynamite-shot in a shot-hole might be accomplished by this enclosure of the charge in water.

With the kind assistance of Mr. William Smethurst, I carried on a series of experiments in the Garswood Hall Colilery, near Wigan, in 1880, which demonstrated that, as I had anticipated, the operation of dynamite as a blasting agent was so modified by this mode of applying it, that the coal brought down by small charges enclosed in water, compared favourably, in regard not only to quantity, but also to its condition in respect to size and small proportion of shattered material, with the best results furnished by full powder charges. These results were fully confirmed by others obtained in a more extensive series of trials carried out for the Commission, by Mr. Galloway in the Bute Merthyr Colliery. Many and searching experiments were made, first by myself, and afterwards under my direction by Mr. Galloway, for the Commission, with the view of determining to what extent reliance could be placed upon the non-ignition, by the use of dynamite water-cartridges, of explosive mixtures of fire-damp and air, and subsequently of non-explosive mixtures of air and gas, in which coal-dust was thickly suspended by the action of a blown out shot. The Commissioners' report will shortly deal fully with these important experiments, but I may briefly state that, while *absolute* immunity from danger of the ignition of an explosive gas-mixture by a blown-out shot was not found to be secured by this system of blasting, such was the case in every instance in a large number of trials, when the blown-out shot was projected into air containing fire-damp in proportions approaching that of an explosive mixture, and in which a very inflammable coal-dust was thickly suspended. Results confirmatory of these have been quite recently obtained by Mr. A. R. Sawyer, one of H.M. Inspectors of Mines, at Mill Bank Colliery, with another form of nitro-glycerine explosive, used in the same manner. It has also been found, in the Commissioners' experiments, conducted by Mr. Galloway, that the superposition of the water-tamping, according to Dr. McNab's original plan, over a *dynamite*-charge, appears to afford security against the ignition of a dust-laden mixture of air with a somewhat considerable proportion of gas, and these results have been borne out by experiments recently made by members of the German Fire-damp Commission, consequent upon their learning of the results which we have obtained. In these cases, the comparatively moderate cleaving action of the dynamite, secured by its enclosure in water, and which renders it commercially applicable to coal getting is not secured, but for blasting stone with dynamite, gun-cotton, tonite, or gelatine-dynamite, in coal mines where dust and some proportion of fire-damp may co-exist, the use of water-tamping may prove to be sufficient to afford perfect security.

Even while actively engaged in the completion of their report, the Commissioners are still pursuing this subject experimentally, with the desire of furnishing, as far as in their power, decisive and thoroughly reliable data regarding the amount of security which appears to be afforded by these methods of working, against the most prominent and prevalent sources of danger in connection with the use of explosives in coal mines, and, while I have been engaged upon this address, a still more simple method of applying water to counteract the dangers arising from blown-out shots has suggested itself to Mr. Galloway, preliminary experiments with which have furnished most promising results.

I have now attempted to give you a fairly comprehensive outline of the progress made within the last few years towards a thorough comprehension of the nature and causes of those dangers attending the work in coal mines which most prominently direct public attention to the perils of the miner's calling, and in the advances already made, and still rapidly progressing, towards the provision of the miner with really safe and efficient underground illumination, with efficient substitutes for explosives for a considerable proportion of the work connected with coal mining, and with methods of using explosive agents, where these cannot be dispensed with, so safe that the terrors which have attended blasting in mines may be confidently expected speedily to fade away. Imperfect as this sketch has necessarily been, I venture, therefore, to believe that I have demonstrated that we have made most satisfactory and important progress in all of these several directions, thanks to the labours of professional associations, of scientific and practical experts, and I think I may also say, thanks to the exertions of the Royal Commission on Accidents in Mines.

I have been led to refer more fully than I had first intended to the work which had been performed by the Royal Commission — the results of which, in detail, will shortly be in the hands of the public—because I felt sure that the members of the Society of Arts would take a most lively and sympathetic interest in the labours of men who have not allowed themselves to be discouraged, by unjust attacks and ignorant criticism, from endeavouring to carry to a useful termination the arduous work which, at her Majesty's desire, they cheerfully took upon themselves.

The Commissioners have been silent while hard things have been said of them ; but it were idle to deny that they have acutely felt the injustice reflected upon them by some writers in the public Press who, while posing as judges and philanthropists, have not earned for themselves, by knowledge acquired or by work performed, the right to criticism.

During the four years which have passed since the Commission submitted their preliminary report, several among them have ungrudgingly devoted time which should have been theirs for needful rest from arduous official and scientific work, to pursue the laborious and often discouraging investigations which fell especially to their lot. Thirty years' personal experience of the work of experimental Committees has taught me that *ad interim* reports are not unfrequently worse than valueless, and this would certainly have been the case had the Commissioners attempted, during this interval of time, to make any so-called progress reports, because conclusions or suggestions might have been put forward in them which would have had to be afterwards recalled, or incomplete data given which might have been misleading, and, therefore, even dangerous. As regards the question of the unsafe nature of certain so-called safety lamps, however, I have pointed out that the Commissioners considered it their duty, just five years ago, to report to the Home Secretary in no hesitating terms, in the belief that their statements would have been published,—and it is no fault of theirs that the public was not informed of their strongly expressed conclusions on this subject, but has been, on the contrary, recently told in the *Times* by a well-known mining engineer that the results of the Royal Commission's labours "have not even extended to the official condemnation of the known unsafe lamps."

The daily journals have at any rate chronicled the activity of the Commission by recording the dates and *locale* of their frequent meetings, and have been cognisant, therefore, of the fact that their place of work was easily accessible. This being so, it is somewhat matter for surprise that the writer of very condemnatory paragraphs in an editorial article suggested by correspondence published in the *Times* last June, should not have cared, in the first instance, to inform himself, however imperfectly, of the kind of work upon which the Commission were engaged, and to take that opportunity of seeking some little correct information on the subjects with which his graphic pen was directed to deal. Had he done so, he would scarcely have instructed the public that "a huge majority of colliery accidents arise from explosions;" that "coal mines generate an explosive gas, which, when collected in a quantity, and exposed to a flame, ignites, and blows into fragments the workings in which the vapour and flame meet;" "that every coal mine has its explosive gas," or that "often the miner has opened the door of his lamp to light up the cavern, already perhaps darkening with the heaviness of a gas-laden atmosphere." I will do him the justice to believe that he would not have felt disposed, after even very brief inquiry, to endorse as "not exaggerated" the declaration of the "strenuous and benevolent correspondent," Mr. Ellis Lever, "that the delay in the issue of the Commission's Report was "to the eternal discredit of Royal Commissions."

After all, however, it rests entirely with the public Press to decide for itself whether the ends it has in view are such as to render it desirable to seek for correct information before administering public condemnation.

But, with a public official, especially when connected with the very Department of State most directly concerned in the work of the Commission, the case is very different, and it is scarcely to be credited that the gentleman entrusted with reporting to the Home Secretary upon the circumstances attending the explosion last summer at Clifton-hall Colliery, should not have thought it worth his while to ascertain, by inquiry, which could not but have been of immediate service to him, whether the delay in the completion of the Commissioners' report was "unaccountable."

To this Society, which has always distinguished ifself by its encouragement of earnest workers, and its just judgment of their labours, I have ventured, as one of its members, to make these comments, which could not be uttered by me in my capacity as a member of her Majesty's Commission, whose duty it is simply to report the results of their labours when they have, to the best of their judgment, fulfilled the duties imposed upon them.

Sir **FREDERICK BRAMWELL**, F.R.S., said it was his privilege, as the last surviving occupant of the chair now so worthily filled by Sir Frederick Abel, to propose a vote of thanks to him for the address he had just delivered. The Society was very fortunate in having a Chairman of Council whose scientific training and good common sense entitled him to respect and admiration for the way in which he conducted the business of the Society, and also to the gratitude of all the members and of the public in general for the labours he undertook gratuitously in connection with various inquiries and Commissions, but for which it appeared thanks were not always forthcoming. Naturally, those who did not know the care required in ascertaining the truth in a difficult matter, imagined that all the Commissioners had to do was to sit down and elaborate from their inner consciousness a certain amount of fairly good English, which would form a quantity of printed matter, easy and pleasant to read, but absolutely valueless for any practical purpose. That was the kind of thing an impatient public seemed to want, but he was quite sure all the members of the Society would heartily sympathise with their Chairman, when he described the patience which must be evinced by those who desired to have a really useful report, as this report would be when published, no one could doubt; but that it would have been a great pity, and might easily have been a source of danger, to publish an incomplete report could not be doubted either. In addition to the many labours and discomforts which attended the work of any Commission such as that of which Sir Frederick Abel was a member, involving as it did, work in coal mines under circumstances of great discomfort, and, to some extent, of danger, and the giving up of their ordinary pursuits for the purpose of benefiting their fellow-subjects, it was very hard indeed that these men should not obtain the earnest support and thanks of the public instead of unmerited opprobrium. It was for this Society to endeavour to reverse that course of things, and to give Sir Frederick Abel and his colleagues their heartiest thanks, not only for the work they had done, but also for the wise discretion they had exercised in not publishing imperfect matter, which might only do harm hereafter. They had also to thank the Chairman for the manner in which he had presided over the interests of the Society during his tenure of office last year, and for the very able address he had now delivered.

Prof. **ODLING**, F.R.S., in seconding the motion, said he had listened to the address with very great interest, and recalling many interesting and important introductory addresses which he had heard in that hall, he considered that it was second to none in interest and importance. Sir Frederick Bramwell had well referred to the liberality with which Sir Frederick Abel invariably placed his great attainments at the service of the public in every possible way, as chairman of the Council of the Society, as Chairman of the Jury Commission of the Inventions Exhibition, as one of the most active spirits on the Royal Commission on Mines, and in many other ways; yet there was no man who, with all this liberal use of his superfluous time, was more actively engaged in the proper duties of his office than Sir Frederick Abel. Elsewhere he might enlarge on his many excellent qualities, but these were no doubt well known to all the members, and he would only say that they owed to him that mixture of extensive scientific knowledge, good judgment, and thorough, never-failing, pains-taking, in everything he undertook, which brought about results which, if not very pleasant reading when put before the public, were thoroughly trustworthy from beginning to end. He had not, in his address, enlarged on the great services which he individually had rendered to the working of the Commission, nor told them how much of those valuable experiments had been of his devising, how much his scientific knowledge had led to the suggestion of these various experiments, and how much his own personal courage had assisted in carrying them out at what many men would have considered very considerable risks. On all these accounts, however, he was eminently deserving of the vote of thanks which had been proposed.

Mr. **William Botly** supported the motion, and referred to the forthcoming International Exhibition, and especially to an article in the *Journal* dealing with this subject.

The motion having been carried unanimously,

Sir **Frederick Abel**, in responding, said it was very gratifying to him to find that the subject he had selected for his address had interested the meeting, and that the Society sympathised with him in regard to the important and useful work lately carried on with the view of ameliorating the condition of our miners. He also thanked the mover and seconder for their kind expressions with regard to his efforts to be of use to the Society. As an old member he naturally took a warm interest in the welfare of that great Society, and having been elevated to the position he now occupied, it was his first endeavour to carry out the duties of the office to the best of his ability.

The Lilne Cartridge Company exhibited specimens of their cartridges and apparatus. Mr. Swan also exhibited his safety lamp, and Mr. E. H. Liveing his gas indicator.

The Chairman then presented the following medals:—

The Society's Gold Medal, awarded by the Council of the Society of Arts to Exhibitors at the International Inventions Exhibition, on the recommendation of the Juries:—

GROUP I.

*Sir Henry Bessemer, F.R.S.:—For the invention of Bessemer steel.

*Percy Gilchrist:—For the Thomas-Gilchrist basic process of steel making.

GROUP IV.

Hathorn, Davey and Co., for their domestic motor. (*Medal offered under the Howard Trust.*)

Samson Fox:—For his corrugated iron and steel flues for steam-boilers. (*Medal offered under the Howard Trust.*)

Crossley Brothers:—For the "Otto" gas-engine. (*Medal offered under the Howard Trust.*)

GROUP XI.

Ralph H. Tweddell:—For his system of applying hydraulic power to the working of machine tools, and for the riveting and other machines which he has invented in connection with that system. (*Medal offered under the Howard Trust.*)

GROUP XIV.

*Badische Anilin und Soda Fabrik:—For their improvements in the manufacture of colouring matters and intermediate products from coal tar.

GROUP XXVIII.

William Crookes, F.R.S.:—For his improvements in apparatus for the production of high vacua, and for his invention of the radiometer. (*Medal offered under the Fothergill Trust.*)

GROUP XXXII.

Messrs. John Broadwood and Sons:—For pianos. (*Medal offered under the Alfred Davis Trust.*)

Messrs. Steinway and Sons:—For pianos. (*Medal offered under the Alfred Davis Trust.*)

Messrs. W. E. Hill and Sons:—For Violins and Violoncellos. (*Medal offered under the Alfred Davis Trust.*)

Society's Silver Medal for papers read during last session:—

To **Anton Jurgens**, for his paper on "The Preparation of Butterine."

To **P. L. Simmonds**, for his paper on "Present and Prospective Sources of the Timber Supplies of Great Britain.

To **A. J. Ellis**, B.A., F.R.S., for his paper on "The Musical Scales of Various Nations."

To **Thomas Wardle**, for his paper on "Researches on Silk Fibre."

To **H. H. Johnston**, "for his paper on "British Interests in East Africa, especially in the Kilimanjaro District."

To **E. C. Buck**, for his paper on "The Agricultural Resources of India."

To **Mancherjee M. Bhownaggree**, for his paper on "The Present Condition and Future Prospects of Female Education in India."

To Dr. **Frederick Siemens**, for his paper on "Tempered Glass."

To **Frederick J. Lloyd**, for his paper on "The Chemistry of Ensilage."

Miscellaneous.

INTERNATIONAL INVENTIONS EXHIBITION.

GROUP XV.—GAS, AND APPARATUS RELATING THERETO.

By W. J. Dibdin.

The numerous exhibitions of gas appliances which have been held during the last few years in various parts of England, have so thoroughly disseminated a comprehensive knowledge of the various improvements made from time to time in apparatus both for the manufacture and utilisation of coal gas, that the novelty which one naturally looks for in such an Exhibition as the present has undoubtedly lost its freshness. However, notwithstanding these frequent displays in various industrial centres, the observant visitor to the East Arcade found, amongst many familiar exhibits, much to interest and instruct.

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* These medals were awarded by the Council in consequence of an application from the Jury Commission, who were anxious to carry into effect recommendations from the respective Juries, urging the claims of the Exhibitors to special recognition.

Amongst the inventors of exhibits relating to the manufacture and distribution of gas, the well-known names of Somerville and Waller are deservedly conspicuous as the introducers of numerous valuable appliances in connection therewith. The manufacture of air-gas, *i.e.* air or other non-illuminating gaseous compound, enriched with the vapour of hydrocarbons, was also well illustrated. The apparatus of Messrs. Kirkham, Hersey, and Clark, and that of Messrs. Hearson and Co., who exhibited the "Sun" gas making machine, were both good examples of what may be done in this direction, and are especially adapted for use in places where only a limited quantity of gas is desirable. Although the use of carburetted carbonic oxide is in no little favour in America it has found no considerable support in this country, where the older method of obtaining gas from coal is preferred. The poisonous character of carbonic oxide is one of the chief, if not the only objection to its use, as, in the event of a leak from bad fittings, disastrous results are likely to ensue; although this does not seem to be a practical objection in the newer country.

After the various improvements in methods appertaining to the manufacture, of illuminating gases, the measurement of the quantity used by the consumer calls next for attention. The two systems of meters in use, namely, "wet and dry," were well represented, the exhibit of Messrs. Glover and Co. being very instructive as showing the various improvements in details of construction. Messrs. Foxall, Llewellin, Jones, and Co. exhibited a new pattern of dry meter in which the leathers open to a greater extent than in the older forms, thus ensuring slower action. In the three-light meter constructed on this principle, one foot of gas is passed in six revolutions, whereas eight revolutions are required to pass the same quantity through one made on the usual pattern. The principal characteristic of a good meter is that it should continue to register accurately under varying pressures and speeds, a result which is very satisfactorily obtained by the system adopted by Messrs. Foxall and Co.

Messrs. Cowan's self-regulating wet meter has a definite capacity within wide limits, irrespective of the height of the actual water line. This result is obtained by the use of a small inner drum, which, at reduced water levels, withdraws the excess of volume of gas, and returns it into the space under the hollow drum, where it mixes with the gas entering by the spout, and with it forms the supply to the succeeding and filling chamber.

The much vexed question of meter indices has also received considerable attention. Mr. Grey exhibited an improved index in which the dial hand ends in an open circle embracing the number to be read, thus infallibly indicating the correct reading As so many of the public profess themselves unable to read the ordinary form of index, this system will doubtless be welcomed. The interlocking arrangement in the wheels is very simple and ingenious. Other excellent forms were exhibited, but none surpass Mr. Grey's in simplifying the, to many, difficult task of reading the meter indications, and thus checking the operations of that mysterious being, the "gas-man."

The ready method by which gas-meter indices may be tested before being attached to the meters was admirably shown by Messrs. Cowan's "Tester." In this arrangement a whole series of indices may be readily examined simultaneously by means of a simple train of wheels. The experience of gas-meter inspectors has long pointed to the desirability of some such system being made compulsory. It not infrequently happens that the remarkable increase or decrease in the gas bill, after the fixing of a new meter, is explained by some one of the train of wheels having been misplaced, or another wheel from a different system having been accidentally introduced; a mistake which it is often impossible to discover during the testing of the meter by the ordinary legal methods. This is one of those minor matters calling for legislation, but which, in the hurly-burly of political discussion, is pushed aside until a "more convenient time."

The importance of controlling the supply of gas to the consumer's fittings is now beginning to be generally acknowledged, and many forms of regulators, or "governors," are before the public. The two competing methods employed are the "mercurial" and "leather diaphragms." In the first the diaphragm is is an inverted cup, constructed either of metal or glass, floating upon a surface of mercury, whilst in the second form the flexible leather is attached to a metallic centrepiece which sustains, as does the metallic cup in the mercurial governor, the pin supporting the valves regulating the flow of gas. Some six or seven exhibitors showed specimens of their various specialities, which are all excellent in their way, and would go far to satisfy the requirements of those who habitually complain that the companies "force" gas through their burners. The comfort afforded by the judicious use of a good governor is only appreciated by those who have one properly fitted. The disagreeable singing of the burner is at once stopped, and a steady, noiseless illumination obtained.

Next after the meter and governor the burner naturally claims attention. The exhibits of the various flat flame, Argand, and inverted recuperative burners were exceedingly interesting, the latter especially so. Messrs. Sugg and Co. made an admirable display; their "Cromarty" and "Vincent" burners, constructed on the latter system, being especially noticeable and interesting, as affording a high "duty" with a small consumption of gas, thus bringing into a practicable form the invention of Dr. Frederick Siemens, who, as is well known, was the first to adapt the regenerative principle to gas-burners. The Wenham Patent Gas Burner Company also exhibited a fine series of burners constructed on the same system, but having essential points of difference. The exhibit of this company included burners suitable for ordinary dwelling rooms, with others of larger size, giving very high duties, for the illumination of halls and other large spaces. Mr. George Bower had evidently abandoned the whilom much talked of Grimston burner, which took the gold medal at the Crystal Palace Gas and Electric Exhibition, in 1882. Messrs. Kirkham, Hersey and Clark exhibited the "Clark" burner, which has survived the ordeal of time, while its competitor, the Grimston, is now considered out of date. The special point in connection with this form of recuperative burner is its suitability for railway carriages. In view of the numerous satisfactory substitutes for the wretched oil lamp so fondly adhered to by many of our railway authorities, it is surprising that greater advance has not been made in the lighting of railway conveyances. The dismal glow which still finds favour on many of the main lines is such a constant source of annoyance and vexation of spirit to helpless railway travellers, that it is to be hoped some speedy reformation in this direction will take place. The recuperative principle, as applied to gas illumination, affords one more aid to the solution of the problem, and want of knowledge cannot be put forward as an excuse for the continuance of the old-fashioned, and long since condemned oil lamp.

The various forms of burners constructed on this system are all so nearly alike in principle as to puzzle anyone not an expert to explain the difference between any two. Whatever their points of disagreement, however, they are alike in one important factor, in that they are admirably adapted for assisting in the ventilation of the room in which they are fitted, whilst the products of combustion may be carried away by the same system. Those who have the misfortune to work for hours in a badly ventilated room, lighted with the usual three or five burners, cannot do better than try this great improvement in gas illumination and ventilation. A good soft, or powerful light may be obtained at will, with perfect freedom from those distressing sensations so commonly experienced. The great objection which some have to the use of gas, by reason of its destructive effect on furniture, frames, &c., caused by the presence of sulphur, is completely overcome by this system, and perfect immunity secured to the most delicate plants. In addition to these great advantages, the remarkable development of the illuminating power of coal-gas must not be overlooked. While an ordinary flat-flame burner will yield a light equal to two or three candles per cubic foot of gas consumed, some of these burners will afford as much as seven or eight candles per cubic foot, which, by the judicious use of reflectors, may be increased, in particular directions, to fifteen candles per foot.

The utilisation of bye-products produced in the manufacture of gas, in increasing its illuminating power, was well shown by the Albo-Carbon Company, who made a very neat display. The pure colour and brilliance of the light obtained by their system has long since obtained for it a firm hold on the public favour.

The exhibits of photometers and other instruments for ascertaining the illuminating power and quality of coal-gas is well worthy attention, the stalls of Messrs. A. Wright and Co., and Messrs. Sugg and Co., deserving in themselves far greater notice than the limits of the present report permit. The universal photometer of the former firm, devised by Mr. Hartley, is a great advance, for experimental researches, on the ordinary form, affording the means, as it does, of estimating the illuminating power of rays emitted from a luminous point at various downward angles. This result is also arrived at by the travelling photometer of Messrs. Sugg and Co., which has been largely used for estimating the quantity of light afforded by various electric and other systems *in situ*.

The standards of light are naturally prominent. The various discussions which have taken place on this subject set forth the necessity for a revision of the existing system. The competing proposals of Mr. A. Vernon Harcourt, Mr. Methven, the late Mr. Keates, and Messrs. Sugg and Co., are illustrated in the exhibits of Messrs. Wright and Messrs. Sugg. In connection with the proposed standard of Mr. Harcourt, the "Table Photometer" devised by that gentleman was shown, in which the relative positions of the standard of comparison, and the light to be tested as well as that of the screen, are fixed; the adjustment being made by burning sufficient gas in the standard burner to afford a volume of light which shall exactly balance on the screen that thrown thereon by the standard pentane flame. The actual consumption of gas required to produce a flame equal to sixteen candles being taken as the indication of its illuminating power. The results are stated in per-centage value instead of "candle power" as by the present legal system, 100 per cent. being equal to sixteen candles.

Amongst the mechanical appliances in this group was the ingenious patent lock connection exhibited by Messrs. Garratt and Fowler. The ordinary union joint possesses a very serious fault, viz., that, on screwing up the nut, the lining also revolves, causing the attached hose, or pipe, to kink or twist. The "lock" connection effectually remedies this defect, the lining and guide having an hexagonal form instead of the ordinary round one, thus effectually preventing the objectionable twist of the guide, and enabling the union to be screwed up much more tightly than is possible with the usual pattern. The same firm also exhibited an improved blow lamp, which can be used in any position with safety, and is useful for wiping joints in positions where it is impossible to work with irons, &c. A smaller form of this lamp is useful also for gas-fitters, as it dispenses with the objectionable and dangerous rushes commonly employed.

The automatic gas lighting and extinguishing apparatus of Messrs. Caink was an interesting exhibit, providing for the lighting and extinguishing of gas at any distance from the burners, without the necessity of providing separate supply pipes, or electric wires, for any considerable distance, the battery employed being placed conveniently near to the burner, and actuated by raising or lowering the gas pressure by means of a governor. The automatic pressure-changing gas governor, of the same firm, is an exceedingly ingenious contrivance, and seems well calculated to answer its purpose. It is constructed on the principle of obtaining an outlet pressure varying in the same direction as the consumption, the alteration in pressure being obtained by a system of self-acting syphons, which transfer the water from the inner to the outer chambers, or *vice versa*, according to the pressure on the outlet.

It is impossible, within the limits of a short review of the leading features of the many adjuncts of the gas industry which were shown at the Exhibition, to do more than briefly glance at the more prominent features that were presented for inspection. A thorough treatise on the various subjects would alone do justice to them, and to the energy and ability displayed in the production of so many ingenious contrivances, all well calculated to further the better manufacture of the primary article, gas, and its most advantageous application. The remarkable development in the various forms of burners introduced during the last decade is in itself a subject of considerable interest, made more so than would otherwise have been the case by the recent introduction into practical use of the electric light, a means of illumination which has perhaps done more for the development of gas illumination than any previous competitor.

FISHERIES OF THE SEA OF AZOFF.

The fisheries of the Sea of Azoff were renowned in former ages. Herodotus and other historians allude to them, and Strabo states that the fish from the delta of the Tanaïs (Don) was an important article of commerce between ancient Greece and Rome. In more modern times, the Little Russians became engaged in this branch of industry, and for many years the right of fishing on the coast was disputed by the different settlers, who often made desperate attacks on each other. Consul Wagstaff says that the chief fishing grounds are in the Bay of Taganrog, and along the coast of the Rostoff district. During the year 1883, the number of hands regularly employed in the fishing trade in the Taganrog district was 2,084, and, besides these, 2,412 men, farm labourers and fishermen, find employment after harvest time at the fisheries. The trade during the winter is usually remunerative, as fish are sent to market throughout the country in a frozen state. Towards the close of the season it is salted, afterwards dried, and sent into the interior, and this description of food is in great demand among the working classes. The salting of fish and curing of *balik* (dried salted sturgeon) was carried on by careless ignorant peasants, until, through the influence of Prince Woronzoff, persons were brought from abroad, chiefly from Holland, to superintend the work, and at the present time it is conducted in a very efficient and cleanly manner. Fishing is divided into two classes—red and white. To the first belong the three kinds of sturgeon—*bélonga*, *sevringa*, and *osétyor*—from which balik, caviare, and isinglass are made; sterlet is rare. The white fish consist of perch, bream, carp, *Cyprinus vimba*, roach, razor fish, and several other smaller species. Sturgeon is caught from May to June, and from September to November, when they are in good condition; the *bélonga*, weighing from 500 lbs. to 550 lbs., yields from 16 lbs. to 25 lbs. of caviare in summer, while in winter from 54 lbs. to 72 lbs. are extracted. White fish are taken all the year round; the roach and *Cyprinus vimba* principally in spring and autumn; the razor fish in summer, and the bream and perch in winter. There are four classes engaged in the fishing industries; first, fishermen who have their own boats and tackle; second, those who have neither, and who hire themselves out on various conditions for the season; third, fish jobbers; and fourth, land and other proprietors possessing fishing stations. The tackle employed consists of seines, 400 to 500 fathoms long; nets 12 to 20 fathoms, and hooks, the last two being in general use, whilst the first are owned only by large proprietors and the chief fishing stations. Besides the tackle, there are fishing boats of different sizes and construction, from the six to eight oared launch, or *baidaky*, costing about £30 to the *kaiouk*, which may be purchased for £7. The boats are built during the summer by men who come from North Russia, but they require constant repairs. The small boats fish along the coast, and the larger boats 20 to 50 miles from their stations; each fishermen has to attend to from 7,000 to 10,000 hooks. In winter, fishing is carried on on the ice up to 40 miles distant from the station, and the whole of the coast during that season, from Taganrog to Yeisk, is a scene of great activity, sometimes as many as 20,000 men being employed, and from 3,000 to 5,000 horses. The following is the system of winter fishing. From fifty to sixty nets are taken on a sledge with three to seven days' provisions, and fodder for the horses. Holes are made in the ice about fourteen inches in diameter seven paces apart, and a rope to which the nets are fastened, is passed by means of a pole pushed along underneath the ice from hole to hole. The first long narrow hole is the most important, as the pole has first to be introduced into it; afterwards a place is cut for drawing up the nets, which are generally twelve to twenty fathoms long, and four of these are placed in a line. The nets are secured at each end to a pole driven into the bottom of the sea, and also by a grapline, with a pointer fifteen fathoms long. This system is adopted by the poorer fishermen, but large proprietors establish fishing stations, huts for men, &c., and use principally seines which are put down in the form of a horse-shoe, commencing from the tip where the body of the seine is dropped, working towards the two ends in the same manner as the small nets are laid, and they await the arrival of the shoals of fish. The two ends are then brought near each other, and hauled up through a large hole, which is encircled with nets to prevent the fish from escaping. The average value of fish annually taken in the province of Taganrog amounts to about £80,000; but including the Delta and Lower Don, the total value of the fish ranges between £300,000 to £400,000 annually.

Notes on Books.

THE PAPER MAKERS' DIRECTORY OF ALL NATIONS. Edited and compiled by Charles Phillips. London. 1885-6.

This is the second issue of the "Directory of Paper Makers," which contains a notice of 4,296 mills. Of this number 369 are in the United Kingdom, 512 in France, 1,037 in Germany, 378 in Austro-Hungary, 194 in Italy, 148 in Russia, and 1,122 in the United States. The countries which contribute only one each to the grand total are Andorra, Mauritius, Syria, Egypt, Cuba, Demerara, and Greece.

THE TECHNICALITIES OF THE ART OF COACH BODY-MAKING. By John Philipson. London. 1885.

Mr. Philipson has here amplified a paper which he read before the Institute of British Carriage Manufacturers. His little book is fully illustrated, and contains a description of the chief varieties of carriages.

CHRISTMAS CARDS. Hildesheimer and Faulkner, 41, Jewin-street, E.C.

The publishers of Christmas cards are now ready with their wares intended for distribution next month. The early appearance of these cards has frequently been remarked upon, and Messrs. Hildesheimer and Faulkner have printed an explanation of this. They say, in the first place, that many cards are required in October and November for sending to friends abroad, and they themselves require to have the cards ready in the first months of the year, so as to be able to send samples to America and the colonies, and they add, "our specimen books for the home trade had to be issued in May, to enable the wholesale houses to obtain their orders from the retail stationers throughout Great Britain and Ireland, for delivery about October." It appears that publishers' preparations for the production of the cards have to be made more than twelve months before the cards are offered for sale in the shops, as it requires five to nine months to lithograph and print each set of three or four designs. The designs for the present year's cards were purchased by Messrs. Hildesheimer and Faulkner between November, 1883, and November, 1884. The artists are the Misses James, M. Dealy, Alice Havers, Linnie Watt, and Alice West; Messrs. Albert Bowers, Frank Feller, Fred Hines, W. J. Hodgson, C. G. Noakes, F. C. and A. Price, Percy Robertson, B. D. Sigmund, and Ernest Wilson. The subject of the cards are landscapes and seascapes, trees and flowers, scenes of old travelling, children at play, soldiers, &c., and the forms are varied, some represent palettes, others folding frames, &c. The majority of the cards are in colours, but some are in sepia.

CHRISTMAS AND NEW YEAR CARDS. Davidson Brothers, 9, Jewin-street, E.C.

The cards produced by Messrs. Davidson are bright with colour, and consist chiefly of landscapes and flowers, and children at play. There are winter land scenes and water scenes, and figures of fishwives and highland pipers. Some have views upon them, and others music; in one the wires supported by telegraph poles are made to do duty for the musical staff.

THROUGH THE MEADOWS. By Fred. E. Weatherly, illustrated by M. E. Edwards, vignettes by J. C. Staples. London: Hildesheimer and Faulkner.

This volume contains a collection of verses by Mr. Weatherly, illustrated with monochrome vignettes in the text and also full-paged coloured plates.

THE WHITE SWANS, and Other Tales. By Hans Andersen, with illustrations by Alice Havers. London: Hildesheimer and Faulkner.

These are a selection from Andersen's fairy tales, translated by Mrs. H. B. Paull, and they are printed with tinted illustrations in the text and full-paged coloured plates in addition.

HISTORY OF PRICES SINCE THE YEAR 1850. By Michael G. Mulhall. London: Longmans. 1885.

Thirty years ago Tooke and Newmarch's "History of Prices" was completed, and Mr. Mulhall has now taken up the subject of the rise and fall of prices since 1850. In dealing with the precious metals, the author states that the fall in silver is because plate has gone out of fashion, "that prices are not regulated or affected by the amount of metallic money per inhabitant, and that we make 20 shillings of coin in Great Britain do as much trade as 85 shillings in France, 40 in Italy, 58 in United States, or 100 in Spain." This book is fully illustrated by diagrams showing the range of price-levels.

THE PRACTICAL TELEGRAPHIST. By William Lynd, with an appendix on the application of Gravet's Slide Rule to Electrical Testing. London: Wyman and Sons.

In his first chapter the author describes the different batteries used in telegraphy, and subsequent chapters are devoted to the single needle instrument, reading by sound, the universal battery system, testing, &c. Mr. Preece, F.R.S., contributes to the volume an account of Duplex Telegraphy, and Mr. James Graves one on Ocean Telegraphy. The volume is illustrated with diagrams.

INTERIOR DECORATION: A Practical Treatise on Surface Decoration with Notes on Colour Stencilling and Panel Painting. By Fred. Miller. London: Wyman and Sons.

In this work the author deals but slightly with structural points, his object being chiefly to show how the architectural details already present in house can be best treated by the decorator. The decoration of walls and ceilings forms a large portion of the subject, and the various points that arise in respect both to the design and the colouring, are here treated of.

CHRONOGRAMS CONTINUED AND CONCLUDED; more than 5,000 in number, a supplement volume to "Chronograms," published in the year 1882. By James Hilton, F.S.A. London: Elliot Stock. 1885.

When Mr. Hilton published his previous volume, in 1882, he thought that the subject was practically exhausted, but renewed and continued research since then has brought many more chronograms to light, so that he is able now to publish a volume equal in size to the original one. In these two volumes it is calculated that about 21,000 instances are quoted or alluded to, and the author has given a list of books not accessible, in which many further chronograms will probably be found. The subject of this book is so intimately connected with history, that it naturally contains much information respecting historical events. The volume is also fully illustrated with facsimiles of titlepages of books, portraits, &c., containing chronograms.

General Notes.

INDUSTRIAL REFORMS IN RUSSIA.—A recent enactment has prohibited night work in factories, as far as women and young persons are concerned, the limit of age in the latter case being seventeen. It is stated, however, that the application of the new law will at first be limited to cotton and wool spinning establishments and linen weaving factories. It is in contemplation to open weaving schools in many industrial centres, and thus afford Russian workpeople that technical training in which they have hitherto been deficient.

SHIPS' SIGNALS.—Mr. Donald C. Grant, one of the Forth Bridge staff, according to the *Engineer*, is bringing out a new form of signal for use at sea to indicate to other ships the direction of movement of the helm, so as to avoid collision with ships close up. He does not propose to supersede the side lights at present employed, but only to supplement them. The officer on watch is supplied with a couple of signals small enough to be carried in a breastcoat pocket of ordinary capacity. Should he wish to indicate that his vessel is on the port tack, he takes a signal—with a round handle and coloured red—from his pocket and fires it by giving it a slight tap. The result is a brilliant red light. After this light has burned for about thirty seconds it explodes a small maroon, the report of which can be heard a mile off; and after this the light continues to burn for another thirty seconds. The process of firing the starboard tack signal is, of course, the same, the result being a green light, but in this case the handle is square, this difference of form making it easy in the dark to distinguish the right signal to be employed.

COAL-FIELDS IN THE NORTH OF FRANCE.—The total output of coal from the mines in the North of France for 1884 was 9,430,000 tons, as against 10,050,000 tons in 1883, this being equivalent to a diminution of rather more than 6 per cent. According to the returns which have come to hand for the first six months of the present year, this decrease is likely to be still more marked, and at the same time there has been a falling off in the quantity of coal imported, amounting to about 11 per cent. for last year. According to the returns published by the Minister of Public Works, the number of miners employed in the Northern coal mines is 47,152, out of a total of 113,000 for the whole of France. The amount of money paid annually to them in wages is £5,080,000, this being equivalent to £49 for each man, but while in some of the southern coal mines, notably in the department of the Gard, the wages amount to £51, they fall as low as £43 10s. in the Nord. This sum does not include indirect additions to wages, such as house rent at a reduced rate, medical relief, coal, &c., which cannot well be put into figures. The average cost of raising the coal is sa nearly as possible 5s. a ton for the whole of France, but while it is as low as 3s. 10d. in the basin of the Allier and 4s. 2d. in the Pas de Calais, it reaches 6s. 6d. in the coal mines of the Gard. The average annual output of each workman is 263 tons for the whole of France, being 320 tons in the department of the Aveyron, 293 tons in the department of the Gard, and only 287 tons in the Pas de Calais. Many of the French coal mines appear to be worked at a loss, for the official returns for 1883 state that while 190 realised a total profit of £1,712,287, the 125 others showed a loss of £253,722. This leaves a balance of £1,458,565, which represents a net profit of about 4½ per cent. on the capital invested.

MANUFACTURE OF WRITING MATERIALS.—At a meeting of the Académie des Sciences, M. de Boutarel read an essay upon "Paper and the Industries connected with it," in the course of which he quoted some statistics as to the rapid increase in the quantity of pens, paper, pencils, &c., which are manufactured in Europe and the United States alone. M. de Boutarel says that the manufacture of paper, which at the beginning of the century was practically *nil* in the United States, now amounts to 500,000 tons per annum, and that it is just double this figure in Europe; the value of the straw, rags, and other materials used in the manufacture of the paper being £20,000,000. M. de Boutarel estimates the value of these 1,500,000 tons of paper, when manufactnred, at £40,000,000; the note paper being calculated at 120,000 tons, worth £6,400,000. M. de Boutarel estimates the value of the steel pens manufactured annually at £800,000; while the number of heliotype plates may be safely estimated at 3.000,000—thirty Paris houses alone turning out 900,000.

SULPHUR MINES OF SWOSZOWICE.—According to an article by Göbel (*Oest. Zeits. für Berg-u-Hüttenwesen*, 1885, s. 14), all work at these mines is suspended, the present price of sulphur precluding their being carried on at a profit. The mine, two kilometres south of Cracow, was commenced as long ago as 1422. The workings are in the Jurassic formation. There are two layers of sulphur-yielding earth, each composed of a dark grey marly clay, through which the sulphur is distributed in the form of concrete masses, varying in size from 1 in. in diameter to no larger than poppy seed. These beds are separated by a vein of fibrous gypsum fluctuating between three and six fathoms thick. The roof is of clay containing petrifactions, and enclosing lumps of sulphur weighing as much as 3½ lb. The total depth is about 30 fathoms. The sulphur yield averages 10 per cent. The smelting of the crude mineral is performed in gallery furnaces, the yield being approximately 6½ per cent. For some years past the product has been consumed locally for making carbon bisulphide, which is largely employed as a phylloxera cure throughout the grape-growing districts of the Austrian empire. (See the *Journal* of July 11, 1884.)

PAPER RAILS.—The *Organe des Mines* states that a company is about to establish large works for making rails from paper near St. Petersburg. The paper is subjected to great pressure, and it is said that the material is extremely durable, and can be produced at one-third the cost of steel rails. A further advantage would be in their lightness, not only on account of the saving of the cost of carriage and laying, but also because they could be made in longer lengths than is the case at the present time, therefore the number of joints would be fewer, and consequently less oscillation to the carriages, and the wear and tear to both permanent way and rolling stock reduced to a minimum. A greater adhesion also would be offered by these rails to the driving-wheels of the engine, and the working expenses reduced accordingly.

MEETINGS FOR THE ENSUING WEEK.

MONDAY, Nov. 23...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. (Cantor Lectures.) Mr. John Mayall, jun, "The Microscope." (Lecture I.)

Surveyors, 12, Great George-street, S W., 8 p.m. Mr. Edward Smyth, "The Copyhold Enfranchisement Bill, 1884-5."

Inventors' Institute, Lonsdale-chambers, Chancery-lane, W.C., 8 p m. Adjourned discussion on the Patent Act, 1883.

Medical, 11, Chandos-street, W., 8½ p.m.

Asiatic, 22, Albemarle-street, W., 4 p.m.

TUESDAY, Nov. 24...Civil Engineers, 25, Great George-street, S.W., 8 p.m. 1. Mr. John Imray, "High-speed Motors." 2. Mr. Gisbert Kapp, "Continuous-current Dynamo-Electric Machines, and their Engines."

Medical and Chirurgical, 53, Berners-street, Oxford-street, W., 8½ p.m.

Anthropological, 4, St. Martin's-place, W.C 8 p m.

WEDNESDAY, Nov. 25...SOCIETY OF ARTS, John-street, Adelphi, W C., 8 p.m. Silvanus P. Thompson, "Apparatus for the Automatic Extinction of Fires."

Royal Society of Literature, 4 St. Martin's-place, W.C., 8 p.m.

THURSDAY, Nov. 26...Royal, Burlington-house, W., 4½ p.m.

Antiquaries, Burlington-house, W., 8½ p m.

Telegraph Engineers and Electricians, 25, Great George street, S.W, 8 p.m. Mr. J. A. Fleming, "The Necessity for a National Standardising Laboratory for Electrical Instruments."

FRIDAY, Nov. 27...Quekett Microscopical Club, University College, W.C., 8 p.m.

Clinical, 53, Berners-street, W., 8½ p.m.

SATURDAY, Nov. 28...Physical Science School, South Kensington, S.W., 3 p.m. 1. Mr T. Mather "The Calibration of Galvano-meters by a Constant Current." 2. Mr. A. Hilger, "A New Driving Clockwork of Isochronous Motion, and on a New Direct-vision Spectroscope." 3. Mr. C. V. Boys, "A Machine for the Solution of Equations." 4. Mr. H. H. Cunyngham, "A Machine for the Solution of Cubic Equations."

Botanic, Inner Circle, Regent's-park, N.W., 3¾ p.m.

CORRECTION.—P. 1134, col. 1, for Empire Club *read* St. George's Club.

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FRIDAY, NOVEMBER 27, 1885.

All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

NOTICES.

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CANTOR LECTURES.

On Monday evening, the 23rd inst., Mr. J. Mayall, jun., delivered the first lecture of his course on "The Microscope," when he exhibited a large number of microscopes lent by the Royal Microscopical Society, by Mr. Frank Crisp, Secretary R.M.S., and by Mons. Alfred Nachet. Microscopes were also exhibited in the Library by Messrs. R. and J. Beck, Ross and Co., Swift and Sons, Watson and Sons, and Mr. W. Johnson.

EXHIBITION OF MICROSCOPES.

The historical microscopes shown by Mr. Mayall at his lecture, and the microscopes exhibited by Messrs. R. and J. Beck, Ross and Co., Swift and Sons, Watson and Sons, and Mr. W. Johnson, will be on view during the week, and the Exhibition will be kept open during the period of the delivery of the Cantor Lectures, daily from 10 to 4, and on Saturdays from 10 till 2. Members can admit their friends to the Exhibition by the use of the tickets supplied for the evening meetings and lectures.

UNION OF INSTITUTIONS.

The following Institution has been received into Union since the last announcement:—

Cork Literary and Scientific Society, Royal Cork Institute, Cork.

COVERS FOR JOURNAL.

For the convenience of members wishing to bind their volumes of the *Journal*, cloth covers will be supplied post-free for 1s. 6d. each, on application to the Secretary.

Proceedings of the Society.

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SECOND ORDINARY MEETING.

Wednesday, November 25th, 1885; Captain Douglas Galton, C.B., D.C.L., F.R.S., Vice-President of the Society, in the chair.

The following candidates were proposed for election as members of the Society:—

Colbeck, James, Cork Literary and Scientific Society, Royal Cork Institution, Cork.
Crouch, Henry, 66, Barbican, E.C.
Crowdy, James, 28, Craven-hill-gardens, Hyde-park, W.
Denton, Charles Lord, Orielton, St. Briavels, near Coleford, Gloucestershire.
Glasgow, David, 20, Myddelton-square, E.C.
Hopkinson, James, 95, New Bond-street, W., and Ardlethen, West-heath-road, Hampstead, N.W.
Platt, S. R., Werneth-park, Oldham.
Spurrell, Flaxman, L.R.C.P. Edin., F.R.C.S. Eng., Belvedere, Kent.
Squance, Harry, South Moor, Sunderland.
Squance, Thomas Coke, M.D., 4, Beauclerc-terrace, Sunderland.

The paper read was—

APPARATUS FOR THE AUTOMATIC EXTINCTION OF FIRES.

By Silvanus P. Thompson.

Great fires, like many other misfortunes, come not single spies, but in battalions. London has certainly had its share during the present season. Early in the year came the great fire at Whiteley's—the third or fourth in that famous establishment—and in quick succession there followed the fire at the India Museum, the fire at Messrs. Jackson and Graham's, the conflagration which gutted seven warehouses in Curtain-road, the fatal Bermondsey disaster, the outbreak at Messrs. Maw's, in Aldersgate-street, another Oxford-street fire, the burning of the steam saw mills at Hackney, then the fearful devastation at Clerkenwell (which destroyed at least £120,000 of property, and threw several hundreds of persons out of work), a fire in Tottenham-court-road and, lastly, the great fire at Dock-head, which destroyed one of the finest flour mills in this country.

Nor have the provinces been more fortunate. The fire at the works of the Barrow Shipbuilding Company cost £250,000, and threw 2,000 hands out of work, in Septembe last.

A few days later a warehouse at Bradford was burned, causing a loss of £20,000; then the bleaching works at Church, near Accrington, were destroyed, with a loss of £14,000; after that came the lace factory at Nottingham, with a loss of £20,000; then a great fire at Manchester, in the premises of Messrs. Lewis Behrens and Co., shipping merchants, estimated at £250,000; and lastly, Harwood's cotton mill at Bolton was burned ten days ago, with a loss of £40,000.

In a single season England has to pay at least £2,000,000 as her fire bill; and she pays it complacently, year by year, with all the unreckoned incidental losses, and congratulates herself that the majority of the losses are covered by insurance.

Covered by insurance indeed! As if that made the smallest difference in the long run to the community at large, who practically have to pay for the loss, in the form of higher rates for insurance, and therefore less margins of profit on all manufactures, and even on agriculture.

We all are interested, whether producers, manufacturers, or consumers, in the prevention of great fires. It is a disgrace to our civilisation that such fires are possible.

Naturally, at a time when we have been called upon to pay so dearly, we turn in thought to the systems adopted for the extinction of fires, and begin to inquire whether there is not something radically wrong in our methods of protection, if such gigantic conflagrations still rage so often in our midst. Our fire brigades are none the less efficient than of yore, our engines no less powerful or prompt, our firemen no less heroic. Yet they are powerless to cope with the gravest difficulty of the case—namely, that, by no fault of their own, they usually arrive upon the scene too late to stave off the catastrophe. A night-watcher or policeman observes a glow in an upper storey window, he raises an alarm or runs to the nearest station. There is the fatal flaw in our system. Those first few precious minutes after the outbreak of flame, during which the telegraphic fire-alarm or the telephone has been set to work to summon aid, are the critical moments. All might have been saved had there been a bucketful of water at hand, and an active arm to apply it. To be sure it is not in all cases that nothing can be done before the fire brigade arrives. The old-fashioned fire-bucket, and the more modern *extincteur*—itself a triumph of applied science—are not unfrequently of great service, always provided there is some person present to make use of them. Of late, a still simpler appliance has found some favour with the public, in the form of certain so-called "hand-grenades," or flasks of glass filled with certain mysterious liquors, which when scattered over the flames cause their extinction. I have a vivid recollection of seeing some months ago in a provincial town a travelling agent for these *grenades*, who won great applause by setting up in a public square a wooden shanty filled with combustible materials—brushwood, tarred barrel staves, and shavings soaked with paraffin oil. These he set alight, and when the flames appeared to have taken fierce hold, he advanced a few paces and quietly tossed into the blaze half a dozen of the brittle vases, which, in bursting, discharged their contents and rapidly suppressed the flames. A solution of tungstate of soda or phosphate of ammonia forms a suitable liquid for fire extinction; but I have heard one more sceptical of the chemical fraternity roundly declaring that the precious fluid thus sold to the public at the rate of five shillings per gallon was only sal ammoniac and water! Certainly, the grenades produce surprising results, but they are of little use save in the very earliest stages of an outbreak. At the fire at the India Museum some hundreds of them were fruitlessly thrown into the flames, and caused great subsequent annoyance by reason of the fragments of broken glass which strewed the scene. But, at the best, there is the same objection to grenades as to extincteurs and fire-buckets, namely, that they do not set themselves into operation; they are absolutely useless until some person arrives upon the scene to put them into operation.

There is nothing, absolutely nothing, in all these things that can act for itself. The fatal two minutes or five minutes that elapse before help arrives are past, and help comes too late. *Nothing but a self-acting or automatic system, which will operate at the right moment and at the very spot, without the intervention of any human hand, will meet the case.*

It is, therefore, with the automatic methods of extinguishing a fire at its first outbreak that my paper deals.

Modern automatic appliances for the prevention and extinction of fire may be grouped under the following heads:—

(1.) Automatic Sprinklers.
(2.) Automatic Fire-doors.

(3.) Automatic Alarms.
(4.) Miscellaneous Appliances.

I.—AUTOMATIC SPRINKLERS.

Foremost and most important of modern appliances stands the automatic sprinkler. Lest any person among my audience does not know what automatic sprinklers are, let me briefly say that they are a species of self-acting valves connected with a system of water pipes placed in the ceiling of a room, which, on the outbreak of a fire, open and distribute water in a shower of spray exactly at the place where the fire breaks out. The automatic sprinkler is also usually arranged so that, whenever it is called into operation by the heat, it sounds an alarm bell, and summons aid to the spot. It is both fire extinguisher and fire alarm in one. Concerning it, Mr. Edward Atkinson, the well-known statistician, who occupies the honourable position of president of the Boston Manufacturers' Mutual Fire Insurance Company, says, "we consider the automatic sprinkler the most valuable auxiliary appliance, the best fire detector, the watchman who never sleeps, and the device which is least likely to be out of order when needed." This is high testimony indeed, yet not too high, considering that the automatic sprinkler is the most rational—I had almost said the only rational—means yet invented for extinguishing a fire at its first stage. The saving effected in New England alone during the past eight years by the introduction of sprinklers is calculated to amount to a million and a half of dollars, or about £300,000, and their use is extending every day. Careful inquiry shows that the introduction of sprinklers reduces the risk of conflagration by fire to less than a twentieth part. That is to say, the loss in England during the past summer and autumn by large fires, estimated—and probably much under-estimated—at £2,000,000, might have been reduced to £100,000, had sprinklers been fitted in all the establishments which suffered. The extraordinary thing is that *in not a single one* of the factories, warehouses, and mills enumerated, were there any automatic sprinklers at all!

The earliest suggestion for the automatic distribution of water in a building appears to have been made in 1806 by John Carey, of London, who took out a patent for "the extinguishment of fires in gentlemen's apartments and warehouses" by means of rose sprinklers connected by pipes with a rain-water tank. Valves weighted to open, but held back by a combustible cord, were placed near the ceiling, so as to burn and turn on the water. A few years later, Sir Wm. Congreve took out patents for a system of distribution of water by bulbs, roses, or perforated pipes, supplied by water-mains through valves operated from outside. He also proposed to work valves automatically by cords, which were secured with "a cement fusible at 110° (F.) or less."

In 1852, one William Maccaboy proposed a kind of sprinkler, in which the water was distributed by a rotating "mill" like a Hero's engine, covered with a cap of lead, gutta-percha, or fusible alloy. Rotating sprinklers have been subsequently patented by Granger, Parmelee, and others.

In 1861, Louis Roughton patented a sprinkler having a rose-head with a neck plugged with a fusible substance, such as fusible alloy, or a mixture of wax, resin, and stearine.

In 1864, Captain A. Stewart Harrison, of the 1st London Engineers, produced an excellent form of automatic sprinkler, which embodied a good many of the principles in the more recent forms which are exhibited here. Harrison's sprinkler consisted of a rose, through the perforations of which the water would be forced; but an internal valve held back the water, the valve itself being secured by solder. But it should be noted as an important point that Harrison secured the valve at the lowest point of the sprinkler, outside the rose, by a stem, which passed downwards through the sprinkler.

Another form of sprinkler, introduced by Mr. F. W. Whiting, has a conical or hemispherical rosette, covered by a thin metal cap, soldered all round the edge. The water pressure tends to tear the soldered flanges apart.

About the same time—1863 or 1864—the sprinkler began to come into real use in New England. In 1863, the Tremont Mills at Lowell, Massachusetts, were fitted with a system of pipes distributing water from an elevated cistern along the ceilings of every floor, the pipes being perforated at intervals with fine jets, through which the water, when turned on, issued in spray. In this mill there were two miles of perforated pipes, divided into nine sections, any one of which could be turned on separately by hand. In each section were about 1,650 orifices, calculated to discharge 450 gallons per minute over an area of 10,300 square feet, or about four gallons per minute per hundred square feet.

It may be here remarked that 100 square feet, *i.e.*, an area ten feet square, forms a convenient unit of reference in connection with the distribution of water by sprinklers.

There were several powerful objections to the methods adopted up till that time. With impure water the perforations of roses or pipes were liable to choke; and in the case of iron pipes, rust produced the same effect. The ingenuity of inventors was called out to meet these difficulties. Harrison countersunk the orifices in his rose; Whiting patented a plan of letting eyelets of brass into the orifices; Burritt devised a method of dislodging sediment or dust by means of a thimble with a rounded end, which, when detached by the melting of the solder, is churned round inside a perforated rose by the action of the water.

A more serious defect was that the water in the sprinkler or pipe, by its near presence to the solder, abstracted the heat and delayed the opening of the valve. This had indeed been positively obviated in the forgotten sprinkler of Harrison, by the interposition of a block of wood between the water-valve and the soldered joint on the stem.

Another defect arose in some cases, where india-rubber was used as the material of the valve, from the clogging of the valve on its seat. Mr. Woodbury,* who made a most exhaustive series of tests for the Boston Manufacturers' Mutual Insurance Company, on sprinklers of all kinds, states that it required a pressure of 65 lbs. per square inch to make some of these valves open.

In 1875, the Boston Manufacturers' Mutual Company issued a pamphlet recommending sprinklers to their clients, although the chief forms to that time were comparatively imperfect. But their use spread rapidly from that date.

In 1874, Mr. H. Parmelee introduced a sprinkler which, though now superseded by more sensitive arrangements, did good service, and is still in considerable use. It consisted of a metal cap sealed down with fusible solder over an upright revolving turbine-jet. At a pressure of 10 lbs. per square inch this sprinkler discharges 1½ cubic feet of water per minute.

The obvious requisites of a good sprinkler are that the solder should fuse at a low and well-defined temperature, without any appreciable prior softening; that the mechanism should not be liable to get out of order or stick; that the parts opened by heat should be capable of ready replacement without skilled labour; that there should be no leakage at the valve; and, lastly, that the quantity of solder to be melted should be small, and so placed that it is not cooled by contact with too great a mass of metal, or exposed to the drip of the opening valve.

Now, the Parmelee sprinkler takes a considerable time to open—over two minutes usually—owing to the length of the solder seam, and the mass of metal near it; yet concerning it, Mr. Atkinson says:—"The Parmelee sprinkler is shown, by the tests made by Mr. Woodbury, to be about the least sensitive head on the list, and the least in capacity of discharge; and yet the whole experience with the Parmelee sprinklers has been a success, the discharge of water has sufficed, and we have no record of a fire getting away from them."

If such is the fact with the least sensitive sprinkler, what result may we not expect from the later forms of sensitive types of sprinklers? More than 160,000 of the Parmelee have been used in the States, and several mills have been fitted with them in England. The Alexandra Cotton Mill at Bolton was saved by them in July last.

The sprinkler invented in 1881 by Frederick Grinnell showed a marked advance in many details, and soon superseded the Parmelee. By the kindness of Mr. James Sinclair, I am able to show you several samples of this sprinkler, and of its supply-pipes. Each sprinkler is calculated to supply an area of 100 square feet.

In the Grinnell sprinkler, the valve, a leaden disc affixed to the centre of a larger disc of brass, is held up against the valve orifice by a system of two curved levers, the lower of which is secured by fusible solder at its lowest point to a light metal frame (Figs. 1, 2, and 3, p. 43). The valve-seat is itself made elastic by the device of fixing it in the centre of a diaphragm of thin, hard metal, perforated for that purpose; and the pressure of the water upon the diaphragm keeps it tight against the valve. The larger disc attached to the valve-disc serves as a deflector. When the solder is melted, the levers fly apart, and the valve and deflector drop about half an inch, leaving space for the water to escape. It dashes against the disc, which is notched, and slightly dished at its edges, and is then deflected upwards in spray towards the ceiling, whence it falls to the floor. When the sprinkler has worked, it requires to be re-soldered. It seldom requires more than 15 seconds to elapse before the levers fly under the influence of a direct flame. With an ascending hot column of air, the sprinkler seldom waits for a whole minute before it works. In the very short time that has elapsed since this invention was introduced, it has entirely superseded the Parmelee. There are now more than 300,000 of these in the States, and more than 30,000 in Great Britain, chiefly in the Lancashire cotton district, but also in a number of factories and warehouses in London.

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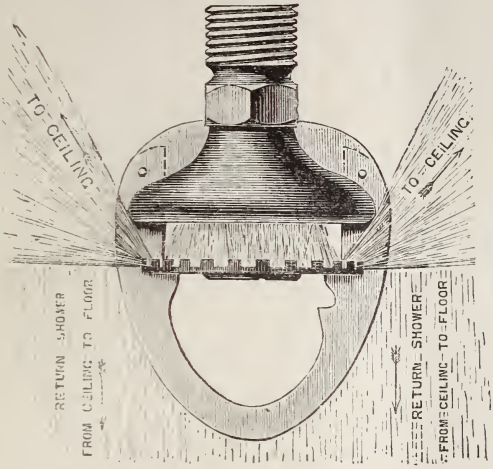
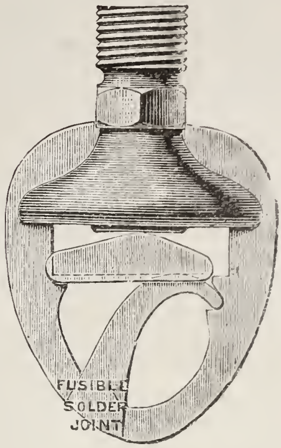
* The writer here desires to acknowledge his indebtedness to Mr. C. H. J. Woodbury, of Boston, not only for the valuable information contained in his report to the Boston Mutual Company, and in his lecture delivered in March, 1885, to the Society of Arts of Boston, but for much personal assistance in collecting information, and for a number of the American devices exhibited at the reading of this paper.

FIG. 1.



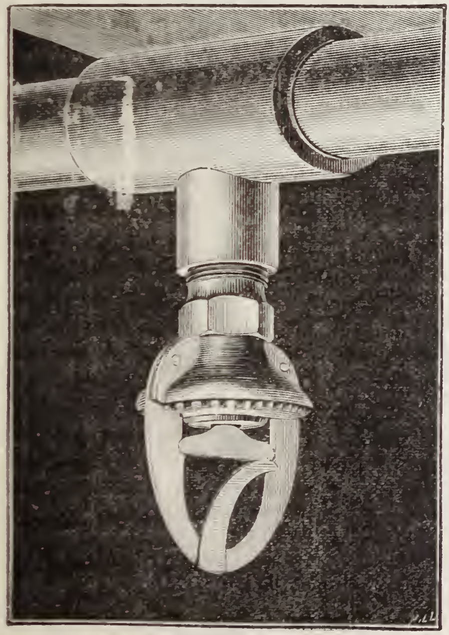
GRINNELL'S SPRINKLER OPEN.

FIG. 2.



GRINNELL'S SPRINKLER CLOSED.

FIG. 3.



THE GRINNELL SPRINKLER IN POSITION.

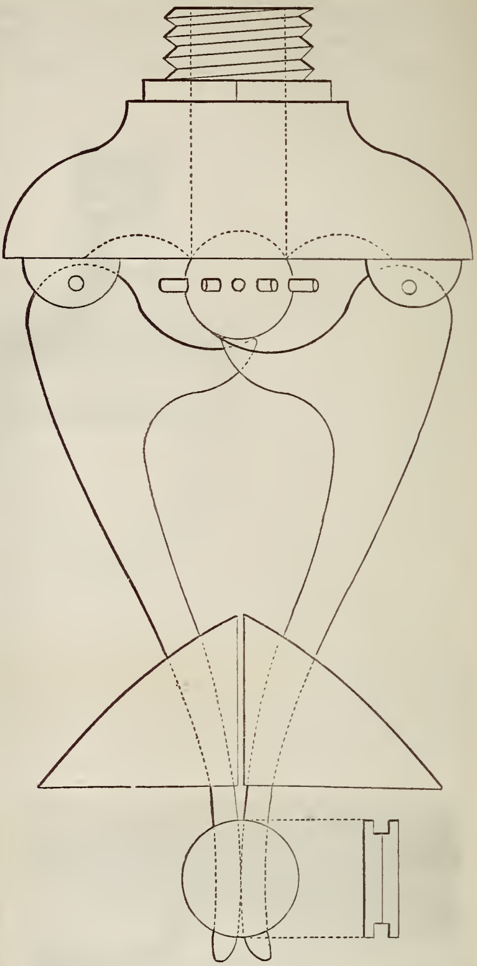
The success of the sealed Parmelee and the sensitive Grinnell sprinkler have been such as to arouse the emulation of inventors to produce other forms of sprinkler. In the States the sprinklers of Harris, Brown, Bishop, Burritt, Ruthenburg, and Walworth are more or less known, though in less extensive use than either the Parmelee or Grinnell forms. In the Harris, Brown, and Burritt (sensitive) forms the valve is held up by a soldering which holds up the valve-stem somewhat as in Harrison's original plan. In Ruthenburg's sprinkler a pair of levers, clamped by a bit of fusible tube, hold up an indiarubber ball. In the Walworth sprinkler the valve-stem is held up by a cam worked by a lever which is either soldered to the body of the sprinkler, or else clamped by an oval link of fusible metal. This latter device is good in so far as it enables the sprinkler, after working, to be closed up again by merely slipping on another ring without the need for skilled labour or the removal of the sprinkler from the ceiling; but the oval ring of alloy is liable to distension and fracture, as the alloy is somewhat brittle, and will not stand much tensile stress

Indeed, the question of alloys must be considered from several points of view, as the most fusible alloy does not necessarily possess the greatest tenacity or the most sharply defined melting point. A piece of Grinnell solder tested in my laboratory was found to fuse at 73·75° C; it was tough and even flexible;

whilst a Walworth link, which melted at the slightly lower temperature of 71·65° C., was not nearly so tough. Professor Guthrie's "eutectic" alloy, which fuses at 158·9° F, or 70·5° C, was not found to be so tough or to have so sharply defined a melting point as some alloys of slightly higher melting point. Of course it is an advantage, from the point of view of sensitiveness, to work with an alloy that has a very low melting point, but it must not be so low as to risk being melted with the ordinary temperatures at the ceiling of a gas-lit room. Obviously, an electrically-lighted mill may be fitted with sprinklers that are more sensitive than those which can be used in gas-lit mills. Conversely, in drying houses and store-rooms special solders with higher melting points are preferred. Progress in the perfection of the automatic sprinkler has not been confined to the other side of the Atlantic, and in addition to the American forms which I have exhibited and explained to you to-night, there are several English forms —all of them so new as not yet to have obtained any wide use—well worthy of notice. In one of these, the invention of Mr. Sydney Smirke, architect, a valve is used resembling the valve of the Victor system presently to be explained, and the water when admitted by the valve is forced between the narrow annular space between two metal dishes, the upper one of which is capable of adjustment.

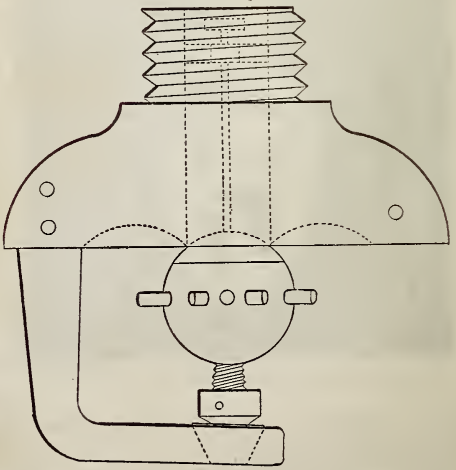
I have also here a number of ingenious sprinklers invented by Mr. Philip Jolin, engineer, of Bristol, who, fired by a lecture given by me, on the automatic methods of fire extinction in the spring of the year, set himself to produce a sprinkler which should be, if possible, more reliable and sensitive than any yet made. (See Figs. 4 and 5.) The form which promises best success has a lead-topped ball valve held up against the supply orifice by a pair of springy metal levers, which are clamped below by a fusible clamp. This clamp, which is readily replaced after the sprinkler has worked, is of an ingenious form, in which the solder is relieved of all direct tearing stress. It consists of a button, made in two parts, soldered at the edges right and left, and admitting the ends of the levers by an aperture which passes from top to bottom. This bottom is protected beneath a divided cone, which serves partly as a deflector for the water, partly as a protector to the clamping button, partly as a collector of the ascending hot air. When the levers open, the valve ball drops a short distance and

FIG. 4.



JOLIN'S SPRINKLER WITH REPLACEABLE SOLDERED BUTTON-LINK.

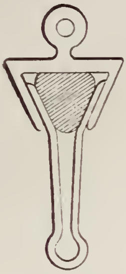
FIG. 5.



JOLIN'S SPRINKLER WITH CONICAL ALLOY PLUG.

operates as a deflector. In another form (Fig. 5, p. 44), a small truncated cone of alloy holds up the deflecting ball to its seat. In yet another form invented by Mr. Jolin, the levers are held together by a double link of brass (Fig. 6), the two parts of which are prevented from parting by a wedge of alloy, subjected only to compressing and shearing stresses, not to tensile stresses.

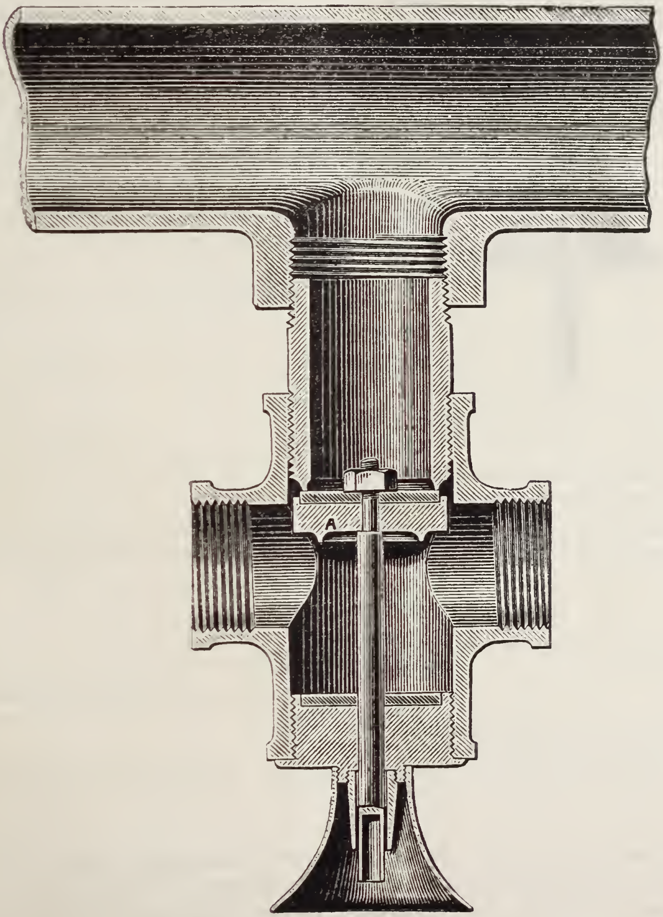
Fig. 6.



Jolin's Fusible Link.

Closely allied to the automatic sprinkler proper, is the system of sprinkling by perforated pipes through an automatic valve. This system, first made practical by a deceased American inventor, Leonard, has lately come to the front under the name of the "Victor" system, and before you are the forms of valve, and of perforated pipe which it employs. As shown in the accompanying figures (Figs. 7 and 8), the valve is held up, as in Harrison's plan, by a soldering at the lower end of the stalk, and this soldering is surrounded by a collecting cone of metal. On the fall of the valve, the water rushes into the long pipes, and is distributed in jets through its perforations. One valve

Fig. 7.

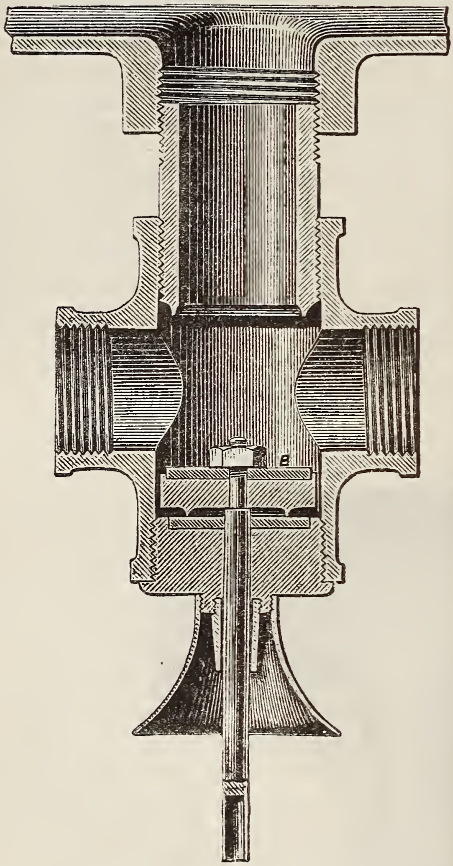


The Victor Valve (closed).

suffices for 400 to 500 square feet of surface protected.

There are several useful adjuncts employed in connection with these appliances. Grinnell fixes in his main pipe, between the supply tank and the sprinklers, a valve arranged to be moved by the water whenever, on the opening of any sprinkler, the pressure is relieved. This valve then sets a loud gong in motion, and sounds an alarm. Electric alarms are also used in connection with sprinklers.

Fig. 8.



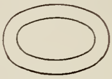
The Victor Valve (open).

II.—Automatic Fire-Doors.

I now pass to the next item. Fire-doors may be made automatic. The Boston Company have investigated this question by their experts, and have pronounced most emphatically against iron fire-doors. They say they curl up and keep out the water and men, and allow the fire to spread. They announce the opinion that a well-built wooden door, protected by tin plate on each side, is much better; the wood will not burn, but it becomes charred, holds the tin together, and keeps out fire better than an iron door would. They make it automatic in the following way:—The door is arranged to slide shut on an inclined track, and is kept open by a rod, which is made with a scarf-joint in two parts, united in the centre inside a copper ferrule or sleeve which nicely fits the two ends of the rod. The joint is shown in Fig. 9. This sleeve is made in longitudinal halves, which are secured together with fusible solder. The ends of the rods where they come together are cut at an angle of 45 degrees, and therefore tend to force the sleeve open when the solder melts. One end of the rod is fastened to the door, and the other end to the door-frame. Another device for holding a fire-door open is the fusible link.

The oval link (Fig. 10) used in the Walworth sprinkler is unsuited to stand a tensile stress.

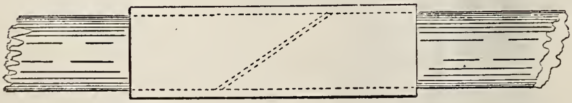
Fig. 10.



Walworth Link of Fusible Alloy.

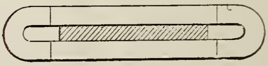
The Grinnell link (Fig. 11) is well suited for this purpose; it consists of two links stamped in thin brass, laid over one another so as to overlap throughout three-fifths of their lengths; they are soldered together, and the central portion is filled up with a bit of copper wire and with solder. These links are introduced into some convenient part of a cord which holds up a weight, the falling of which releases the fire door.

Fig. 9.



Scarf-jointed Rod united by Sleeve Soldered with Fusible Solder.

Fig. 11.



Grinnel Link Soldered with Fusible Alloy.

III.—ELECTRIC ALARMS AND DEVICES.

I now come to some electric devices. We all know Mr. Edward Bright's arrangements for fire alarms, and what excellent things they are. I need only refer you to the papers Mr. Bright has read before the Society of Telegraph Engineers to give you the best authority on the subject. There are several more recent things; one, a very good fire alarm, was exhibited at the Exhibition by Mr. Martin; another, known as Rowley's, has come into the market, and Grinnell has applied an electric alarm in the form of a fusible link. He introduces somewhere into the electric circuit a little link, which may be made of a thin strip of alloy, in some place near the ceiling; on melting, it breaks the circuit and rings an electric bell, if it is arranged to work in a closed circuit, and there you have a fire signal of the first order. This is used in England. There is another open circuit system used in connexion with small Grinnell installations; it is arranged so that when the heat reaches a catgut band strained inside a copper tube it contracts, and makes contact between two strips of metal which go to an electric bell.

Then, still more recently than any of these electric systems, there is one quite new, to which I can only just refer—the invention of Mr. Lorrain. He does not choose yet to make the whole of it public, but he has kindly sent me four diagrams to illustrate the system. It is based upon a system for making an electric contact. The diagrams on the wall show a little thermostat arrangement with a strip of two metals soldered together, which, when they are hot, bend and touch a contact screw, making the electric circuit complete. They do not simply ring a bell; that is a good device for calling, of course, but there are plenty of other things which an electric circuit may do. On the next sheet there is an arrangement shown of an electro-magnetic solenoid; it is a coil of wire with an iron core, which is attracted in when the circuit is completed. When that core is attracted in, it bears on a valve, which is intended to perform the following function:—There is a tank containing sulphuric acid, of course constructed of some acid proof substance, such as stone ware. The valve allows a little acid to trickle into a lower chamber, where there is already a solution of carbonate of soda, and this generates an enormous amount of carbonic acid, which flies up through pipes, and so, with or without water, will immediately cause a great distribution of spray of carbonic acid (which itself is a splendid extinguisher of fire) all over that part of the factory. The next drawing shows a centrifugal arrangement for distributing the water, which is turned on, and is caused to rotate by a small electro-magnet, which is also automatic. And the last diagram, which again is an independent piece of apparatus, quite distinct from the others, represents a very strong cylinder charged with compressed carbonic acid, having a valve weighted, but propped up by a little trigger arrangement below. Directly the electric circuit is complete by the arrangement I first described, the electro-magnet below the cylinder attracts its armature, lets off the trigger, the weight falls, turns on the valve, and you immediately have carbonic acid either distributed through pipes or led directly into the open air. These systems of Mr. Lorrain have not yet, as far as I am aware, been tried, but possibly he may be able in a little time to explain his system more completely to the world.

IV.—MISCELLANEOUS APPLIANCES.

Then passing from the electric arrangements, we come to some miscellaneous ones, of which there are one or two here. Here is one of Mr. Jolin's devices to take the place of the Grinnell link. Here is the little button I spoke of, in which the edges of the brass disks receive the thrust, and take off the stress from the alloy. When it is required for use in a cord to hold up a valve lever or a fire door, it is provided with a couple of loops to attach it to the cord It is readily replaceable after the fire has burned out, and would be a little more reliable, I think, than the Grinnell link. Another contrivance I have here, also of Mr. Jolin's, looks like a little electric lamp hung up, but it is not; it is an arrangement to make a grenade automatic. My greatest objection to these grenades is that they do not throw themselves, and they do not easily break. Now, Mr. Jolin wanted to make these grenades self-acting when a fire broke out, therefore he proposes to hang a grenade up in a sort of cage at the top of the room, the cage being provided with a small button held together with fusible alloy. When that is affected by the ascending hot air, the button bursts open, the cage opens and allows the grenade to fall, and directly the grenade falls, an iron weight follows after it, and breaks it in mid air and sprinkles the liquid about. How many of these would be required in a room I do not yet know, but it is a thoroughly automatic device, and comes strictly within the scope of my paper.

I have also here sent me for exhibition—although I do not know that they are very automatic—a number of interesting devices for the prevention of fire. Here, particularly, is some non-inflammable wood, which has been carried through a process called cyaniting. I have also sent to me, from the United Asbestos Company, a number of samples of asbestos cloth and objects painted with asbestos paint, to show that they will not burn. The cyanite is not a paint on the outside, but this asbestos paint is, and is a very effectual paint; the wood may be charred, but still we do not have any flame from it, and of course that means that the fire, if it spread at all, will spread very slowly.

It is now time to consider what results have been attained by the use of automatic appliances, in particular by automatic sprinklers, by automatic fire-doors, and by pumps set in motion by automatic appliances. And for information on this subject we must look to that part of the world where the automatic sprinkler has been mostly used—New England. But the statistics of the New England insurance companies, and in particular of the Boston Manufacturers' Mutual Company, show no uncertain record. The latter company gives accounts of the fires—over one hundred in number—occurring on protected property insured with them, between the years 1877 and 1884. The average loss per fire was only 331 dollars. Property protected by sprinklers, but insured in non-mutual offices, came off still better, the average loss per fire, for the same period, being 327 dollars only. From the statistics of the same offices for the same period of years, it appears the loss per fire on non-protected property was 7,700 dollars; that is to say, if a fire broke out on non-protected property it did about 23 times as much damage as a fire breaking out on protected property would do. If these figures have any meaning at all, they mean that *the premiums sufficient to cover risks on property protected by automatic appliances need only be* 1-23*rd part as high as they now are on non-protected property*. What factory or mill-owner would not willingly reduce his premiums to a shiling in the pound of the present rate? It would be a good investment, indeed, to put up sprinklers, as the saving on insurance would cover the interest on the outlay and charge of maintenance two or three times over. The greatest reduction I have yet heard of, in the premium charged by any English insurance office, is 33⅓ per cent., but a still greater reduction would pay well.

And if automatic sprinklers can do so much in saving property in New England, they can do the same in Old England too. Already, indeed, they are beginning to do it.

The following is an account of a fire at a Bolton cotton mill in July last:—

> A fire occurred at the Alexandra Mill, belonging to Mr. John Butler. The preservation of the mill from perhaps total destruction is attributed by the proprietor and other competent judges to the action of an appliance known as "Parmelee's Sprinklers," patented and invented by Messrs. Parmelee Brothers, of the United States of America. The Alexandra Mill—which was built about twenty-two years ago, and contains 35,000 mule spindles, employing nearly 200 operatives—was fitted throughout with the sprinklers something like two years ago, being extended over every ten square feet from the top to the bottom storey, and fixed near the ceiling. The apparatus consists of ranges of pipes, running lengthways and breadthways, and at each end of the side branches is affixed a rose in a fusible casing. The plug or cover of the sprinkler is made to melt at a heat of from 150° to 160°, and when this occurs the water is liberated, and dispersed over the burning material in thick spray The fire broke out near the centre of the fourth pair of spinning mules on the third floor—two storeys above the card-room—and so sudden was the manifestation that the entire wheelgate, which extends about 100 feet, was a mass of flame in two or three seconds. The hands engaged in the room, with praiseworthy courage, instantly began to attempt to check the fire by means of buckets of water; but, finding all their efforts ineffectual, they quitted the room, which was by this time densely filled with smoke. The last man had only just darted into the staircase when some of the sprinklers over the mules where the fire arose came into operation, and this had an immediately beneficial effect. The fire-engine was not brought into requisition, only a few jets from the adjoining street hydrants being used for a few minutes to extinguish the smouldering cotton and other material which had remained in isolated parts of the room after the flames had been overcome by the sprinklers.

Concerning this case, the owner of the Alexandra Mill, Mr. John Butler, writes as follows:—"Without the Parmelee Sprinkler, which was affixed some two years ago, this mill would certainly have been destroyed. Such of the hands as had presence of mind to contend with the flames, being overpowered, had to beat a hasty retreat, when forthwith the heat put the sprinklers into play, one by one, as the fire was spreading, and in five minutes entirely extinguished it. I may say it was confined to the pairs of mules in the third storey in which it began. I have always felt sure that the mill was safe with this sprinkler, and on Thursday the result fully justified me. In future, should a similar accident unfortunately occur, all the operatives will grapple with it more coolly, being sure that the floors will not be burnt from under their feet."

I might give many other cases, did time and space permit.

It may be asked—If there are all these automatic things which will put fires out in the incipient stage, why is it that they are not more known? Why are they not put everywhere, if they will reduce fire-risks to one-twentieth? Automatic arrangements of this kind are thoroughly reliable, always provided they are properly put in, with an independent supply, and no rooms left unprotected. Not leaving a cellar or an attic unprotected, because fires do break out in cellars where things are stored, and also in attics, and therefore it does not do to leave the top or the bottom floor without protecting it. But it is said—Why do not you have every factory that stands on its own ground protected from top to bottom? It must be because people do not know how good a protection science can offer. But another reason is that the insurance offices of this country have obstructed this most desirable reform.

I have made this statement, and the truth of it has been challenged, that fire insurance companies are not good friends to scientific progress. That there may be no doubt of the truth of my statement, I will read a letter which was sent to me by a gentleman who had gone to the expense of £400 in putting sprinklers into his establishment:—

> "We have fitted our works with nearly 400 sprinklers, at a total cost (with an independent tank) of about £400. When the surveyor of the ——— company called to look us over, we pointed them out to him, and suggested that some rebate should be allowed to us. He only jeered at them, and considered them of so little importance that he would allow us nothing at all. He is endorsed in this by the ——— and ——— companies. May we venture to trouble you by asking you if you had any office in your mind at the time you wrote that statement?"

Of course I had. I knew there were thoroughly reliable offices (though it is not my business to advertise them) which will make a rebate and do make rebates. I believe there is not an insurance company in this country that would not find it to its interest to make a rebate on its insurance in cases of risks of this kind of factories and warehouses, and all places that can be protected by themselves, and which are self-contained, and, indeed, in a great many other cases too. There are one or two cases where mills partially protected have been burned down, but they are instructive as showing that the protection had not been carried out in a scientific way.

The report of the Boston Mutual Company says:—

> "We do not underrate what has been accomplished, and we may affirm that what has been done has already saved losses more than amounting to the cost of the whole service; but we have also lost two mills by fires which originated and gained a completely destructive headway in the lower storeys in which there were no sprinklers, so that the mills fell with the service in the upper storeys in full operation. We now urgently advise sprinklers everywhere in every department of a mill, over wheel-pits as well as elsewhere."

The two cases referred to are, first, that of the woollen mill of Messrs. Craven and Millard, where the fire started in an unoccupied basement, spread to the weaving-room on the ground floor, which was unprotected, and gained such headway that the mill was completely destroyed, although the automatics in the upper rooms kept the fire out of these rooms until the supports gave way below.

The second case was at the Annisquam Mill, where the fire started in the engine-house, spread to the unprotected weaving-room on the ground floor, and destroyed the mill, while the sprinklers in the carding and spinning rooms over were in full operation. This was therefore in reality an unprotected case.

I have tried to show you how modern science has provided mankind with systems of appliances which, if properly used, are thoroughly reliable, and afford a protection which, if not absolutely perfect, is far in advance of the clumsy methods hitherto relied upon. If the new and automatic methods do not cause a revolution in insurance tariffs for factory and mill risks, that will be the fault of the factory and mill owners. And it will be the fault of the public themselves if such a disastrous series of fires as that which marks the year 1885 be ever again permitted to disgrace the annals of London.

That our ordinary methods of extinction of fire should, in the year 1885, be so thoroughly antiquated, as they are, is a blot on our social organisation. But science has shown the means of reform, and her duty ends there. Common sense, whether in the form of written or unwritten law, must now step in and see that the needed reform is carried out.

DISCUSSION.

Captain **Shean** said he had been present at some of the fires referred to in the paper. These sprinklers were certainly very efficacious, if used in the way intended; but at the great fire at Bermondsey, when the first steamer from Tooley-street arrived, it had to wait twenty minutes before water could be obtained; and in the same way, before these sprinklers could be of any practical use, the water companies must be reformed. The Fire Brigade attached as much importance to the safety of life as to the protection of property, if not more; and however efficacious these sprinklers were when fire attacked them, smoke would not put them in operation, and therefore danger to life would still exist. He then drew attention to one of Shand and Mason's hand-pumps, which were in extensive use by the Fire Brigade, and put out about 5,000 fires on the average every year in London. One great difficulty was the great amount of indifference with which any improvement whatever was met with. He had recommended, some time ago, a theatrical manager to introduce one of these hand-pumps, which were not patented, and cost about £3 each. The manager said he certainly would have one, and when he came out of the building, the watchman said they had long wanted one, and was very much pleased with the suggestion; but he passed the theatre six or eight months afterwards, and no pump had yet been provided. There were many mills in Yorkshire where the Fire Brigade Association had recommended simple and inexpensive protections, but they were not adopted; and he thought it was necessary to have a Parliamentary inquiry into the means for preventing fires to bring pressure to bear on the insurance companies who, at present, had a complete monopoly. If people used the appliances which common sense dictated, the insurance companies ought to make some allowance, and if they would not do it voluntarily, they should be compelled.

The **Secretary** said he had received a letter from Captain Eyre Shaw, regretting that he was unable to be present, as he had only that day returned from a voyage, and calling attention to the following paragraph in a pamphlet he published a few years ago on "Fires in Theatres (1876)":—"A few years since an intelligent writer in this country proposed that a series of perforated pipes should be led all over the auditorium for use in case of need. The idea is an old one, but it has not, as far as I am aware, been adopted in more than a very few instances, and then only for extremely hazardous manufacturing operations. Indeed, there can be very little doubt that, with such an arrangement, a great power of destruction by water is placed in the hands of the person in charge of the command-cock, and that, as it makes but little difference to those who are only pecuniarily interested whether the loss is by fire or by water, there is generally very little encouragement to owners of property to adopt this plan. At all events, in the case referred to, the idea was publicly and privately scouted by almost every one who treated of it, and yet the fact remains that, however dangerous to property it might be to have a series of perforated pipes distributed all over the auditorium of a theatre, such an arrangement would make the safety of an audience in case of fire absolutely and completely certain."

Mr. J. **Sinclair** agreed with Professor Thompson that we were much behind the age in dealing with fires. He had paid attention to the subject for the last twenty-one years, and had done a good deal towards introducing small appliances for enabling people to deal with fires themselves. About 95 per cent. of fires were discovered in time to be dealt with in this way, and with that view chemical engines and grenades were introduced. There were thousands of cases in which fires had thus been extinguished. While this was going on, many cotton spinners asked him if there were not some means possible by which fires could be put out in large establishments, when the watchman was asleep or neglected his duties. With that view, he went to America in 1869, to inspect the system of perforated pipes in the mills at Lowell; but he found these pipes were not in favour, because the perforations got corroded in the course of time, and when the water was turned on, some were stopped, and others only emitted an almost invisible stream The great fault, too, was that they had to be turned on by some one. The system Professor Thompson was trying to introduce was one independent entirely of human agency, and having introduced the Grinnell system into this country, he (the speaker) quite agreed with Professor Thompson that, if it were properly used, the day of large fires would be at an end. It was impossible for the sprinklers to fail, because there was no point of weakness about them. As to the water supply, that was provided for by having a tank at the top of the building always full, and not to be used for any other purpose whatever. In addition to that, there was the supply from the main, which in many cases was continuous, but where intermittent, the Worthington pump was adopted. He knew 55 cases of fires which had occurred during the last two and a-half years in America where the Grinnell system had been adopted, and in no case had it failed. The aggregate amount of damage claimed from the insurance companies, instead of being tens of thousands of dollars, did not amount to one thousand on the whole. Some people said the water would freeze in the winter, and, in America, that was a danger, but it was got over in this way. When winter set in, the water was driven back out of the pipes, which were filled with air at eight or ten pounds pressure. There was an equilibrium valve between the pressure of water outside in the main and the air inside. If a fire took place, the sprinkler came into action, the air rushed out, the valve immediately opened, and the water ran in after it, and put out the fire exactly where it occurred. If the fire were too active, and got beyond the radius of the first sprinkler, the next one, ten feet off, would come into operation, but not otherwise, so that there was a perfect economy of water, and the destruction by water was practically *nil*, and need not be taken into account. The only thing the system would not do that a man could do, was to turn off the water when the fire was put out, but it did the next best thing, it started a gong or bell, which sounded the alarm, so that invariably, when the operatives were called together, they had simply to turn the water off. With respect to insurance companies, it must be a surprise to many that the cotton mills of Lancashire had not adopted this system; but just now they were fitting up 23 cotton mills in Lancashire. Some time ago, the insurance companies did not see it to be their interest to make any reductions in the premiums on this account; because they had suffered so seriously for many years past, they could not afford to lessen their income. Then the fire occurred in Bolton, at John Butler's mill, where a sprinkler acted effectually. This created great interest among cotton-spinners, and they immediately wrote to all the companies to know what would be allowed if sprinklers were introduced; and about five weeks ago the companies came to the unanimous conclusion that they must abandon the tariff system in regard to cotton mills, and let every mill be taken on its own merits. That was now being done, and the result was a large application for estimates for these sprinklers. No doubt, in the course of time, the same principle would be applied to other property.

Mr. ALFRED LANGSTON said Professor Thompson ought to be thanked, not only for his paper, but for two letters he had written to the *Times* on the subject. He was interested in the Victor system, which he considered superior to any other, because the water, being supplied through pipes, had a much better chance of covering a given area than when it only came through sprinklers. One objection urged against pipes was that they rusted, but he had it on very good authority that for 20 years an iron pipe had been used in America without the slightest defect. The Victor system, however, was made not only with pipes, but with a rose, and it had the advantage that it could be worked by a key at the end of a pole, and the water stopped. Again, nothing would break the sprinkler; a ladder might knock against it without injuring it or putting it out of shape. At the same time, with each valve there was an electric arrangement which set the bell ringing. With regard to Captain Shean's remark about the water supply, it was always understood, in the protection of large premises, that you had a large tank, holding from 5,000 to 8,000 gallons. This system would practically cover any area, either with one valve to 100 square feet or one to 400; and it had actually reduced the rate of insurance in one case he knew of 33 per cent. That was in a theatre.

Mr. H. BATEMAN said he was much interested in hand grenades, and it had perhaps escaped Professor Thompson's attention that these grenades were to a certain extent automatic. If they were liberally distributed over premises or in small rooms, and a fire broke out, the grenade, if attacked by heat, would burst, and in all probability would extinguish the fire, as had been proved in many instances in America. This was especially the case in lumber-yards, where they had often been placed in drying-rooms. The wood sometimes got overheated and charred, and when the sheds were opened, it was found that a fire had occurred, which had been extinguished automatically. He wished to say, however, that these grenades were not intended to extinguish conflagrations. The advantage of the hand-grenade was, that it provided a means which could be used for no other purpose, and was at once ready to extinguish fire if properly applied. During the short period since grenades were introduced they had endless testimonials showing they were most efficient. He made these remarks because Professor Thompson had alluded to the fire at the Inventions Exhibition, where he said they had failed; and anyone could readily imagine that a small appliance, holding about one pint of liquid, could not be expected to extinguish a large conflagration. At the same time, he was informed that they did good work on that occasion. Only yesterday, a case occurred in London, where a fireman with a hose went up, and found a large amount of inflammable material had caught fire, and had been extinguished by this means. This was another case where the insurance companies did not make any allowance in the premium.

Mr. J. G. LORRAIN remarked that, amongst other objections that had been raised during the discussion, one was the length of time before sufficient pressure was turned on. Now, one function which his apparatus performed, besides those mentioned by Professor Thompson, was to supply pressure where it was wanting. He used the generation of carbonic anhydride in the lower chamber to force the water up to the top of the building. The other methods of having a tank and automatic pump to be called into action when necessary, required expensive apparatus; but his object was to have an inexpensive one. Another objection was that water did as much harm as fire, and that was the object of introducing the bottle of carbonic anhydride. He preferred to use it in the liquid form, as it occupied very little space, but it ceased to be liquid as soon as it came out of the vessel, assuming the gaseous form, and descended like a cloud, extinguishing the fire. Another drawback referred to was that the water was not turned off as soon as the fire was put out. In order to meet that, he had a duplex system of contact, so that, after a certain time, the second electro-motor was set in action to turn off the water.

Mr. LIGGINS thought the most important point was that referred to by Captain Shaw, who pointed out that this beautiful apparatus would be thoroughly useless in the event of there being no supply of water. He could refer to several cases in London where fires had taken place, and no water was available until the place was burned down; amongst others Her Majesty's Theatre, where there was a large iron water-tank at the top, but when the fire occurred it was found to be empty. Another was Covent-garden Theatre, where there was a short supply of water; another was the Royal Exchange. The reason it would have been no use there was it having been severely frosty weather, for he remembered seeing long icicles hanging against the walls of the building close to the flames. He had seen some of the mills in Lowell. It appeared to him they were nearly fireproof buildings. And there was also another element of danger removed from them, because the river which ran through the town had such a flow of water that all the factories worked by water power, and were not therefore obliged to use steam engines and boilers. He agreed with Captain Shean that a hand-pump was a most valuable implement to have, and he had seen many fires in the West Indies extinguished in that way. Most large buildings were protected more or less by watchmen, and he had not much faith in these new inventions, because valves sometimes would not act when they were wanted; and when he saw these complicated little valves, he asked himself whether they were likely to act when they had been up some years. He could not but recollect the accident which occurred on board a man-o'-war in Portsmouth Harbour, where a safety-valve of a boiler got stuck fast through disuse, and 35 men were killed by an explosion. He thought the most important point about the paper was that it would draw public attention to the great difficulty there was in procuring water at the right moment.

Mr. IVEY said it was useless to object to these inventions that they would not act if there was no water, because neither fire-engine nor anything else would act under this circumstance. The important point was, that they would work where a watchman would sleep. If you wanted a watchman to watch, you must watch him yourself. The metal used in the construction of these valves would melt in five or ten years' time as quickly as to-day; and even if it were covered with dust, that would assist the operation by catching fire. The same with regard to the perforated pipes. The holes were supposed to rust; but this would not be so, because they were made of brass; and even if there were any film over the holes, the pressure of water would break through it. The hand-pump was a very good article, but it required two men to work it. If a fire broke out in a factory 500 feet long, a watchman might be at the other end, and would have all kinds of obstacles to pass before he could get at it. Then he would have to call the assistance of another man, and before anything could be done, it might be too late. But with these appliances it did not matter whether the watchman was there or not; he was only required to turn the water off and prevent further damage being done.

The CHAIRMAN, in moving a vote of thanks to Professor Thompson, drew attention to the manner in which most London houses were built, apparently with the view of facilitating their being burnt down. When the Metropolitan Board of Works took such great pains to establish, at an enormous cost, fire-stations all over London, it was very remarkable that it took no pains whatever to insist on the partitions in houses being made to a certain extent incombustible.

The vote of thanks having been carried,

Professor THOMPSON, in reply, said he could not but be gratified at the reception his paper had met with, and especially at the valuable criticism it had called forth. He was much obliged to Captain Shean for the information he had given, but he did not seem to have quite understood one point. It was quite true that the apparatus contained a limited supply of water, but so did everything else. Even a dock was pumped dry at the fire at Dockhead. There must be a limit somewhere, and that contemplated in this apparatus was the tank erected at the top of the building. But in every well organised system of automatic sprinklers, there were two supplies independent of each other; the tank which ought to be constantly inspected, and the supply from the main and some other, in fact that was the rule, and one of the fire insurance companies did make an allowance where this appliance was used. There must be two distinct sources. If it were properly set up, you would not depend on any one supply, and, therefore, were not likely to have a disastrous failure, especially considering the small quantity of water required at the instant. Again, with regard to the fire-pump, one man might pump it, but what was the limit? It was about six or seven gallons to begin with, and you wanted a second man to run continually with buckets of water, and if the water supply failed in the tank belonging to the place itself, it would fail in the bucket. Explosions occasionally occurred in boilers because the tank ran dry, but they were very few. There was a difficulty in keeping tanks supplied for steam-engines—why not for sprinklers? In London, there being an intermittent supply, people were obliged to have tanks, but he hoped there would be a Parliamentry inquiry into the better prevention of fires. One of the first things to be insisted upon would be the reform of the water companies, compelling a continuous supply by meter, for this was a most important point. He hoped they would have that reform whether they had a constant supply or not, and then at any rate they would not be charged for what they did not use. Mr. Bateman had referred to the hand grenades as being automatic. He knew they could be hung up all round the building, and he had seen one building so decorated; but he had also seen experiments in which they did not break when they fell down, and they did not get into the fire at all, and therefore he did not look upon them altogether as an automatic appliance; it wanted something to break the grenade at the moment the fire broke out. Mr. Liggins objected that the valves would not act, and instanced a valve on board a steam-ship which was jammed, but there would be a sprinkler to every ten square feet. In the case of the cotton mill at Bolton, seventeen started at once, so that even if one jammed, there would be sixteen others which had not; but as a matter of fact, not one failed, and they had all been up about two years, quite long enough to rust, if rust did begin. But this could not interfere, for even if they were put in a vinegar factory, where the brass would corrode and become all green, the solder did not corrode, and so long as it stood, all the rest was of little importance. The very thing that must come asunder came asunder, whether there was corrosion or not. He would much rather trust to even the obsolete form of the Parmelee sprinkler, the Grinnell, the Victor, and all the more modern ones, than to the ordinary valve of a steam-engine. The little hand-pump was very nice, but what use would it be in an enormous establishment like Mr. Whiteley's, with one watchman? The fire might break out a quarter of a mile away from where he was, and he would have to make his way all that distance before he could use it. It would be impossible for any watchman, in fact, to keep incessant watch on such a place day and night. The majority of fires broke out, not in the daytime, but either late at night or early in the morning, just at the time when there was no one about, and when even the watchman, who had been watching all night, was most likely to be asleep. There was absolutely nothing but this unsleeping automatic watchman which could relied be on to put out a fire in the incipient stage. That is what was claimed for the sprinkler: it watched for the fire, and put it out in its incipient stage, where it broke out [and when it broke out, and it required no human arm to set it going. Besides this, it gave protection and confidence to the workmen. He entirely appreciated Captain Shean's remarks with regard to the saving of life as well as property, but that was exactly what these things would do, and they prevented panic. If a fire occurred in the day time, they would put out the fire at once; and if it occurred at night, there was no life to be saved, and it was then all important to save property. He hoped if nothing else came of this discussion, it would at any rate draw a little more public attention to the great necessity there was for reforming the water supply.

MEETINGS OF THE SOCIETY.

ORDINARY MEETINGS.

Wednesday evenings, at 8 o'clock:—

DECEMBER 2.—"Technical Art Teaching." By F. EDWARD HULME, F.L.S., F.S.A. Sir PHILIP CUNLIFFE OWEN, K.C.M.G., C.B., C.I.E., will preside.

DECEMBER 9.—"The Loadlines of Ships." By Professor FRANCIS ELGAR, LL.D., F.R.S.E., M.Inst.C.E. Sir EDWARD J. REED, K.C.B., F.R.S., will preside.

DECEMBER 16.—"Burmah, Present and Future.' By HOLT S. HALLETT.

At the meetings after Christmas the following papers (among others) will be read:—

"The Treatment of Sewage." By Dr. C. MEYMOTT TIDY.

"Calculating Machines." By C. V. BOYS.

"The History and Manufacture of Playing Cards." By GEORGE CLULOW.

"Domestic Electric Lighting." By W. H. PREECE, F.R.S.

"The Scientific Development of the Coal Tar Industry." By Prof. R. MELDOLA, F.C.S.

"The Experiments with Lighthouse Illuminants at the South Foreland." By E. PRICE EDWARDS.

FOREIGN AND COLONIAL SECTION.

The Meetings of this Section will take place on the following Tuesday evenings, at Eight o'clock:—

January 26; February 16; March 2, 23, April 13; May 18.

APPLIED CHEMISTRY AND PHYSICS SECTION.

The Meetings of this Section will take place on the following Thursday evenings, at Eight o'clock:—

January 28; February 11, 25; March 11; April 8; May 13.

INDIAN SECTION.

The Meetings of this Section will take place on the following Friday evenings, at Eight o'clock:—

January 22; February 19; March 19; April 2; May 7, 21

CANTOR LECTURES.

The First Course will be on "The Microscope." By JOHN MAYALL, Jun.

November 30, December 7, 14, 21.

The Second Course will be on "Friction." By Prof. H. S. HELE SHAW.

January 18, 25; February 1, 8.

The Third Course will be on "Science Teaching." By Prof. F. GUTHRIE, F.R.S.

February 15, 22. March 1.

The Fourth Course will be on "Petroleum and its Products." By BOVERTON REDWOOD, F.C.S.

March 8, 15, 22, 29.

The Fifth Course will be on "The Arts of Tapestry Making and Embroidery." By ALAN S. COLE.

April 5, 12, 19.

The Sixth and Concluding Course will be on "Animal Mechanics." By B. W. RICHARDSON, M.A., M.D., F.R.S.

May 3, 10, 17, 24, 31.

JUVENILE LECTURES.

The Two Juvenile Lectures on "Waves" will be given by PROF. SILVANUS P. THOMPSON, D.SC., on Wednesday evenings, December 30th, 1885, and January 6th, 1886. Special tickets will be issued for these lectures.

MEETINGS FOR THE ENSUING WEEK.

MONDAY, Nov. 30...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. (Cantor Lectures.) Mr. John Mayall, jun., "The Microscope." (Lecture II.)

Geographical, University of London, Burlington-gardens, W., 8½ p.m. Mr. W. Montagu Kerr, "A Journey Overland from Cape Town across the Zambesi to Lake Nyassa."

British Architects, 9, Conduit-street, W., 7 p.m. Special General Meeting to consider draft of proposed Charter of Incorporation for the Institute.

Medical, 11, Chandos-street, W., 8½ p.m.

London Institution, Finsbury-circus, E.C. Mr. J. E. Hodgson, "The Life and Works of Hogarth."

Royal, Burlington-house, W., 4 p.m. Annual Meeting.

TUESDAY, DEC. 1. Civil Engineers, 25, Great George-street, S.W, 8 p.m. Adjourned discussion on Mr. John Imray's paper, "High-Speed Motors," and Mr. Gisbert Kapp's paper, "Continuous - current Dynamo-Electric Machines, and their Engines."

Pathological, 53, Berners-street, Oxford-street, W., 8½ p m.

Biblical Archæology, 9, Conduit-street, W., 8 p.m

Zoological, 11, Hanover-square, W., 8½ p.m. 1. Mr. John Bland Sutton, "The Origin of the Urinary Bladder." 2. Lieut.-Colonel Swinhoe, "The Lepidoptera of Bombay and the Deccan." (Part IV.) "Heterocera" (concluded). 3. Dr. R. W. Shufeldt, "Contribution to the Comparative Osteology of the Trochilidæ, Caprimulgidæ, and Cypselidæ." 4. Mr. F. E. Beddard, "Preliminary Notice of the Isopoda collected during the Voyage of H.M.S. *Challenger*." (Part II.) "Munnopsidæ."

WEDNESDAY, DEC. 2...SOCIETY OF ARTS, John-street, Adelphi, W C., 8 p.m. Mr. F. Edward Hulme, "Technical Art Teaching."

Geological, Burlington-house, W., 8 p.m. 1. Mr. W. Whitaker, "Some Deep Borings in Kent—A Contribution to the Deep-seated Geology of the London Basin." 2. Mr. G. Wareing Ormerod, "Old-Sea-beaches at Teignmouth, Devon." 3. Mr. F. A. Bather, "Note on some recent openings in the Liassic and Oolitic Rocks of Fawler in Oxfordshire, and on the arrangement of those rocks near Charlbury."

Patent Agents, 55, Chancery-lane, W.C., 7½ p.m. 1. Mr. O. Imray, "The Establishment of a Roll of Patent Agents." 2. Mr. Lloyd Wise, "The Status of our Profession and its Improvement."

Entomological, 11, Chandos-street, W., 7 p.m.

Royal Society of Literature, 4. St. Martin's-place, W.C., 8 p.m.

Archæological Association, 32, Sackville-street, W., 8 p m. 1. Rev. Prebendary Scarth, "Remarks on a Monumental Stone with Greek Hexameter Lines, at Brough." 2. Mr. Thomas Morgan, "Resumé of the Recent Congress at Brighton."

Obstetrical, 43, Berners-street, 8 p.m.

Shorthand, 55, Chancery-lane, W.C., 8 p.m. Mr. T. A. Reed, "Phonographic *v.* Orthographic Shorthand."

THURSDAY, DEC. 3...Antiquaries, Burlington-house, W., 8½ p m.

Linnean, Burlington-house, W., 8 p.m. 1. Sir J. D. Hooker, "*Castilloa elastica* and some allied plants." 2. Rev. Geo. Henslow, "Effects of Solar Spectrum on Transpiration in Plants." 3. Prof. Cobbold, "Parasites collected by the late Chas. Darwin." 4. Mr. P. H. Carpenter, "Variations of the Cirri in Comatulæ."

Chemical, Burlington-house, W., 8 p.m. 1. Ballot for the Election of Fellows. 2. Mr. C. O'Sullivan *(a)*, "The Sugars of the Cereals, and in Malted Grain." *(b)*, "The Presence of Raffinose in Barley" 3. Capt. Abney, "The Evidence of Constitution afforded by Absorption Spectra."

London Institution, Finsbury-circus, E.C., 7 p.m. Mr. C. Armbruster. "The Musical Dramas of Richard Wagner," with illustrations. (Lecture I.)

South London Photographic (at the HOUSE OF THE SOCIETY OF ARTS), 8 p.m.

Archæological Institution, 16, New Burlington-street, W., 4 p.m.

FRIDAY, DEC. 4...Civil Engineers, 25, Great George-street, S.W., 7½ p m. (Students' Meeting) 1. Mr. Maurice Fitzmaurice, "The Foundations of the Forth Bridge." 2. Mr. E. W. Moir, "The Building, Launching, and Sinking of the Queensferry Pneumatic Caissons at the Forth Bridge Works."

Geologists' Association, University College, W.C., 8 p.m.

Philological, University College, W.C., 8 p.m.

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FRIDAY, DECEMBER 4, 1885.

All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

NOTICES.

CANTOR LECTURES.

On Monday evening, 30th November, Mr. J. Mayall, jun., delivered the second lecture of his course on "The Microscope," when he exhibited a large number of modern microscopes lent by the Royal Microscopical Society, and Mr. Frank Crisp, Secretary of the R.M.S.

EXHIBITION OF MICROSCOPES.

The Exhibition of Microscopes will remain open during the period of the delivery of Mr. Mayall's Cantor Lectures, daily from 10 to 4 (on Saturdays from 10 till 2). Members can admit their friends to the Exhibition by the use of the tickets supplied for the evening meetings and lectures.

INDIAN SECTION COMMITTEE.

A meeting of the Committee of the Indian Section was held on Friday, 27th November, at 4 p.m. Present:—Major-General Sir Frederic J. Goldsmid, K.C.S.I., C.B., in the chair; Sir George Birdwood, M.D., C.S.I.; Lord Alfred S. Churchill, Hyde Clarke, Sir William Rose Robinson, K.C.S.I., and J. T. Wood, with H. Trueman Wood, Secretary, and Demetrius Boulger, Secretary of the Section. The programme of papers to be read during the present session was discussed.

FOREIGN AND COLONIAL SECTION COMMITTEE.

A meeting of the Committee was held on Monday, 30th November, at 4.30 p.m. Present:—Hyde Clarke, in the chair, B. Francis Cobb, Lieut.-Col. A. C. Hamilton, R.E., P. L. Simmonds, J. A. Youl, C.M.G., with H. Trueman Wood, Secretary, and Dr. R. J. Mann, F.R.C.S., Secretary of the Section. The programme of papers to be read during the present session was discussed.

COVERS FOR JOURNAL.

For the convenience of members wishing to bind their volumes of the *Journal*, cloth covers will be supplied post-free for 1s. 6d. each, on application to the Secretary.

Proceedings of the Society.

THIRD ORDINARY MEETING.

Wednesday, December 4th, 1885; Lord Alfred S. Churchill, Vice-President of the Society, in the chair.

The following candidates were proposed for election as members of the Society:—

Bedford, George, Art School, Torquay.
Bostock, Edwin, Stone, Staffordshire.
Brenchley, Algeron, M.D., 124, Denmark-hill, Camberwell, S.E.
Chichgur, Darasha Ratanjee, Gergaum-road, Bombay, and 30A, Southbrook-road, Lee, S.E.
Glanville, Francis Ferratus, Grove-house, 140, Fulham-road, S.W.
Hawkins, Major, 51, Harrington-road, Hampstead-road, N.W.
Turpin, Edmund Hart, 6, Argyle-square, W.C.
Westfield, C. Marcus, Sheen-lodge, Warwick-road, Upper Clapton, E.

The following candidates were balloted for and duly elected members of the Society:—

Adames, Cornelius George, Pembroke-house, London-road, Kingston, Portsmouth.
Barrow, Samuel, jun., Fontainebleau, Dacres-road, Forest-hill, S.E.
Bassano, Alexander, 25, Old Bond-street, W., and 12, Montagu-place, Bryanston-square, W.
Beck, Joseph, 68, Cornhill, E.C.
Binns, Richard William, Royal Porcelain Works, Worcester.
Bishop, Frank, 22, Soho-square, W.
Blair, Thomas Edward, Royal Army Clothing Depôt, Grosvenor-road, S.W.
Bond, Henry Cooper, Westwood, Ipswich.
Boys, Admiral Henry, East Dean, Kidbrooke-park-road, Blackheath, S.E.
Brinsmead, John, 18, Wigmore-street, W.
Bromhead, S. S., The Birches, Jasper-road, Upper Norwood, S.E.
Brown, Joseph, Savile Town, Dewsbury.

Burnett, Cuthbert, Burn-terrace, Hartlepool.

Candy, Frank, Leigh-house, Leigh-rd., Highbury, N.

Capel, Charles Cecil, North Cray-place, Foot's Cray, Kent.

Carbutt, Edward Hamer, M.P., Llanwern-house, near Newport, Monmouthshire.

Carey, Arthur, 56, Talgarth-road, West Kensington, S.W.

Carver, James, Garfield-house, Nottingham.

Chater, John, 89, Fleet-street, E.C.

Clowes, William Charles Knight, M.A., Duke-street, Stamford-street, S.E.

Cohen, Nathaniel Lewis, 3, Devonshire-place, Portland-place, W., and Round Oak, Englefield-green, near Staines.

Colby, William Henry, Oak Leigh, Denbigh, North Wales.

Converse, Fred B., 8, Holborn-viaduct, E.C.

Copeland, Major Alfred James, Bridewell Royal Hospital, Blackfriars, E.C.

Corbett, Edward, jun., Ruabon, North Wales.

Cox, John, Hunstanton, St. Edmunds.

Crabb, William, Silloth, Cumberland.

Crofton, Rev. William d'Abzac, M.A., Hillside, Welwyn, Herts.

Crookes, William, F.R.S., 7, Kensington-park-gardens, W.

Crozier, Mrs. (Laura), Grafton-house, Grafton-square, Clapham, S.W.

Curtis-Hayward, Arthur Cecil, Lonsdale-chambers, 27, Chancery-lane, W.C.

Cutler, George Benjamin, 4, Westcombe-park, Blackheath, S.E.

Dornbusch, Ernest G., 35, Stapleton-hall-road, Crouch-hill, N.

Drysdale, Mrs. J. Dockar, 39, Belsize-park, N.W.

Durham, Arthur Edward, F.R.C.S., 82, Brook-street, Grosvenor-square, W.

Edgell-Hunt, H., 8, St. Mary Abbott's-terrace, Kensington, W.

Edmonds, James, 67, Baker-street, W.

Elborough, Alfred Louis, Bedford-park, Croydon.

Ellis, Lieut.-Colonel C. H. Fairfax, R.A., 7, Palace-gardens-terrace, Kensington, W.

Erle, Twynihoe William, 1, Cambridge gate, Regent's-park, N.W.

Essex, Richard Walter, Abbottsford, Thirlemere-road, Streatham, S.W.

Eve, Richard Wafford, M.B., M.R.C.S., 101, Lewisham High-road, S.E.

Foster, Herbert A., Queensbury, near Bradford, Yorks.

Gadsden, Henry Arthur, 6, Crosby-square, E.C.

Gardner, Henry Dent, 25, Northbrook-road, Lee, S.E.

Gates, J. S., 9, Fenchurch-avenue, E.C.

Gay, Frederick William, 113, High Holborn, W.C.

Gray, Thomas, C.B., Board of Trade, Whitehall, S.W.

Greenbank, Richard Hewetson, 18, Leamington-road-villas, Westbourne-park, W.

Grevel, Hermann, 33, King-st., Covent-garden, W.C.

Griffitt, John, Bournabat, near Smyrna, Asia Minor.

Hamilton, Alfred G., Grosvenor-hill, Wimbledon, Surrey.

Haycraft, Alfred Conyers, Westcourt, Lewisham-hill, S.E.

Heath, George, 107, Oxford-street, W.

Heyland, E. Douglas, 25, Liverpool-street, E.C., and 15, Maze-hill, Greenwich, S.E.

Hill, Robert Anderson, Royal Mint, E.

Holt, William Lyster, 17, Parliament-street, S.W.

Honywood, Thomas, Courtenay-house, The Causeway, Horsham.

Innes, John, Greenfield-villas, Llanelly, Camarthenshire.

Jackson, William Lawies, M.P., Allerton-hall, Leeds.

Jacobs, Reuben, 1, Sheldon-street, Bayswater, W.

Jobling, Thomas Edgar, Croft-villa, Blyth, Northumberland.

Kemp, Dixon, 39, Palace-gardens-terrace, Kensington, W.

Kesterton, Vicesimus, 56, Seymour-street, W.

Knowles, Henry, The Shrubbery, Woodville, Burton-on-Trent.

Lawford, George, Sherbrooke-lodge, Nightingale-lane, Balham, S.W.

Lawford, John Eeles, 7, Mowbray-road, Brondesbury, N.W.

Lickorish, Sidney, 17, Highbury-hill, N.

Lyster, George Fosbery, Gisburne-house, Liverpool.

Mac Gauvan, Francis, Salisbury Club, St. James's, S.W.

Maling, Christopher T., 14, Ellison-place, Newcastle-on-Tyne.

Marshall, Julian, 13, Belsize-avenue, N.W.

Masters, W. F., Shenley-lodge, Acre-lane, Brixton, S.W.

Mawe, Frederic H., 2, Willow-grove, Chislehurst, Kent.

Mayne, James, 203, Oxford-street, Sydney, New South Wales.

Medhurst, Sir Walter Henry, Formosa, Kent's-road, Torquay, Devon.

Milne, John Vine, B.A., Henley-house, Mortimer-road, St. John's-wood, N.W.

Milner, Edward, 32, New Cavendish-street, W.

Mordey, William Morris, 144, Disraeli-road, Putney, S.W.

Morgan, Major Joseph Bond, Stand-house, Childwall, Liverpool.

Mylne, Henry Charles, 37, Ebury-street, S.W.

Newton, Henry Edward, 6, Bream's-buildings, Chancery-lane, E.C.

Owen, Thomas, Ellsbridge-house, Keynsham, near Bristol.

Oxley, Frederick, 8, Crosby-square, E.C.

Palmer, Henry, East Howle, Ferryhill, Durham.

Pam, Leopold, 4, Holborn-circus, E.C., and Bohemian-villa, Clapham-park, S.W.

Pennsylvania Museum and School of Industrial Art, Fairmount-park, Philadelphia, U.S.A.

Pixley, Stewart, 21, Leinster-gardens, Hyde-park, W.

Price, Samuel, 38, Walbrook, E.C.

Ramsden, Frederick Frank, Arthur's Club, S.W., and Uffington Rectory, Stamford.
Ramsden, Joseph, The Lion Brewery, Lambeth, S.E.
Redrup, Sidney, Park-street, Windsor.
Riordan, T. Vincent, 1, Whiteley-road, Upper Norwood, S.E.
Robertson, James, 21, Berners-street, W.
Rooper, Maximilian George, 6, Kensington-gardens-square, W.
Schipper, J. F., 10, King-street, Covent-garden, W.C.
Schreiber, Richard, Bloomsbury-mansions, Hart-street, W.C.
Shipley, Mrs. R., Acacia-house, 186, Brixton-road, S.W.
Simpson, Thomas, Silbury-villa, Ravenscroft-road, Beckenham, Kent.
Smith, Sebastian, Shipley Collieries, Derby.
Smithe, Joseph Doyle, 11, Delamere-crescent, W.
Stanley, Christopher Philip, 6, Sussex-villas, Faraday-road, Leyton, Essex.
Temple, Captain R. C., Naval and Military Club, 94, Piccadilly, W., and The Elms, Porchester-gardens, Hyde-park, W.
Testard, Henry, 53, Blackheath-road, Greenwich, S.E.
Thomasson, Ebbe Salvinius, Messrs. Ibbotson Bros., and Co., Limited, Globe Works, Sheffield.
Thompson, A. M., Rossmore, Chislehurst-road, Sidcup, Kent.
Tress, Cooper, West-lodge, Clapham-park, S.W.
Viner, L. L., 54, Westbourne-grove, W.
Waine, Thomas Glover, 139, Newington-butts, S.E.
Waterworth, Alfred, Thorncliffe, Fulwood-park, Preston.
Webster, Charles S. Stanford, Malvern-house, Redland, Bristol.
Welling, Gysbertus, 10, County-grove, Camberwell, S.E.
Winser, Frederic Sawyer, 52, Buckingham-palace-road, S.W.

And as an Honorary Corresponding Member:—

Landreth, Burnet, 21, South Sixth-street, Philadelphia, U.S.A.

The paper read was—

TECHNICAL ART TEACHING.

By F. Edward Hulme, F.L.S., F.S.A.

So much has already been thought, said, and written on this subject, and so much evidence for and against our need of an extended system of such teaching has been brought to bear, that it may perhaps seem the tiresome repetition of a thrice-told tale to endeavour to throw any further light upon the question. It has, nevertheless, struck me that we may still advantageously learn something from the actual teachers, amongst whom I am proud to enrol myself, from the men who have to reduce theory to practice, from those who find themselves face to face with the difficulties, and who are able, possibly, to point to friction overcome, and to some little measure of success achieved. No one can look back ten years, or even five, without feeling that nationally we have already made immense strides in art. Its study is a necessary part of education; we have hundreds of schools of art and art classes in our midst, public galleries thronged, picture exhibitions springing up on every side, excellently illustrated newspapers and magazines, and a crowd of people blocking the pavement in front of every picture dealer's window, while every article of common use, the furniture and wall papers of our houses, the costumes of our wives and daughters, the most trivial things of daily life, have a refinement and beauty stamped upon them that a dozen years ago was utterly unknown. It is easy, of course, to sneer at æstheticism as a passing fashion, and certainly some of its eccentricities deserve the ridicule and scorn of all wholesomely-minded people; but when all that is evanescent and unreal shall have passed away, we shall yet see beneath its frothy emptiness the real strength of the advancing tide. No one, we are sure, who has at all studied the subject, would hesitate for a moment in ascribing to South Kensington a full tribute of appreciation for its noble share in this great art revival. It is not to be wondered at if even "My Lords," those mysterious rulers of the great organisation of the Science and Art Department, have not at all times found themselves unscathed and their actions free from hostile criticism; but the great fact, nevertheless, remains that through good repute and evil, against the dead weight of apathy, the jarring notes of jealousy, and all else of power to hinder the good work done, an enormous, an incalculable, influence for good has been exerted. When I recall the excellent work done by my much esteemed friend, Mr. Sparkes, or my dear old fellow-student and life-long friend, Mr. Rawle, I feel that they, and not they alone but many another earnest worker in the same field, deserve public recognition and the national thanks. Peerages, pensions, K.C.B.-ships, garters, crosses, and the thanks of Parliament have been freely awarded to many who have done less to deserve them. Neither of these gentlemen, I am well aware, has been the agent for the consumption of much gunpowder, or has caused enormous destruction of life and property in a more or less real necessity for the safeguarding of British interests, but other material interests, perhaps as vital, have been to the full as adequately maintained—Mr. Sparkes, I need scarcely tell this Society, has been in the forefront in the creation at Lambeth of a most valuable industry, the Doulton art pottery, that has given healthy work to hundreds and pleasure to thousands; while Mr. Rawle, by his energy and sterling art power at Nottingham, raised the lace trade from a period of absolute dependence, to the tune of many thousands a year, upon French designs, till at length the time came that not only could the old town dispense with such foreign aid, but her designers in turn supplied the needs of French houses, and were sought for far and wide. When we consider how, some twenty years ago, we were always being told that, though our things themselves were probably better made than those of other nations, when it came to a question of art we must meekly stand aside and ask some Frenchman to be good enough to come and do all that sort of thing for us, the revolution we now see is something approaching the marvellous. At this point I can imagine that some of my audience will feel that I am but acting the part of a Balaam, that whereas I have been supposed by them to have come here, even if not quite on a mission of cursing, that at least it was not expected that I should have brought altogether blessing. Pray let me then hasten to explain that I am not so well satisfied with everything as to feel that I need now but " rest and be thankful," but I do desire to raise my voice in protest, at the outset of my paper, against the altogether unjust idea that the schools and system of the Science and Art Department have been proved a failure and must now be swept aside; so far from this, they have been an incalculable gain to the nation, and it now only requires that we should not allow them to crystallise and congeal into a rigid and death-like uniformity, but endeavour to graft into their living structure that additional and more technical knowledge that the necessities of the time and of the place demand. It is, to my mind, sufficiently clear that the instruction given at such places as Paisley, Coalbrookdale, Stoke-upon-Trent, Manchester, and Leeds must in each case have a special bearing upon the special manufactures of the district, above and beyond the teaching of the general principles common to all, if the teaching is to be really valuable.

I suppose in most places it will be conceded that the special and technical art training required will take the form of decorative design, though, of course, in some great centres of industry, such as Crewe, the special direction the work would more naturally take would be the power of accurate delineation and comprehension of all kinds of machinery. At the same time, I would strongly demur to the idea that the teacher should work in too limited a groove. I would affirm that the first test of a true artist is that he should sympathise with all art. The painter who can feel no interest in sculpture, the sculptor who cares nothing for architecture—are in some degree wanting and crippled, even in that to which they do devote themselves. I would desire, too, to strongly combat the idea that decorative art is essentially and intrinsically a lower thing than fine or pictorial art. Hence, then, even your specialist should be a man whose knowledge and powers far exceed his speciality, and whose sympathies extend beyond its routine, for the requirements of the designer are so diverse that occasions will frequently arise to test a man's versatility, and the greater culture and knowledge the man possesses the better, certainly, for his work. Designing is not merely the putting together of more or less graceful forms—not merely an exercise of the hand and of the eye, but considerably more than this; it implies and requires brains at least as much as hands, ideas at least as much as colours and brushes, and a play of fancy that can give grace and meaning to the manual dexterity and flow of line. Some fifty years ago, the things called designs —say, for pottery, or for wall-papers—were of the most atrocious description, because they were the emanations of men without culture, knowledge, or taste; but in view of the high standard that is now called for, the designer should be a man of wide reading, keen observation, and a lover of all that is fine – alike in the whole realm of nature and in the wide field of art.

Your designer, for instance, if he would essay the figure, must have at least as good a knowledge of anatomy as the sculptor or the painter, and be thoroughly familiar not only with the surface forms, but with whatever of inner structure may modify the superficial appearance. A man who cannot tell you all about the *gastrocnemius* or the *pectoralis major*, or sketch you off-hand the femur, is not equipped for his work. The designer, again, must have a good knowledge of plant structure, and, even if he hesitate to call himself a botanist, must be thoroughly acquainted with the leading laws of plant growth. A wild rose spray in all its picturesque beauty, its wealth of colour, is as much constructed according to law as the botanist himself, the spiral growth of its foliage and the beautiful foreshortening of the parts that results from this rigid law is as marked as any anatomical fact; and it is no more permissible to add a sixth to the ring of five fragrant petals in each of its beautiful flowers than to consider it immaterial whether we put four, five, or six toes to the human foot. Lectures on botany, therefore, so far as all appertaining to the growth and form of plants are concerned, should form a necessary feature in a good technical school, and these should not be of the didactic and "out of the book" type, but freely illustrated by abundant blackboard figures, and, as far as practicable, by the handling and passing round of the plants themselves. When once the students have got over the preliminary dread that the whole thing is going to be dry and full of long names, I have always found that such a course is thoroughly appreciated, and there is no difficulty in gaining their attention, or in getting them to fill their note-books.

For many years, and, in fact, until the discontinuance of the botany paper in the examinations required from the art masters trained at South Kensington, I was the examiner in this subject. I select some few questions from my papers, some purely structural, and others bearing on decoration, and I think my hearers will agree with me that such knowledge as the answering of these simple questions involves should scarcely be absent in the case of any who are called upon to instruct others in the theory, principles, and practice of design:—

Stems are ordinarily circular in transverse section. Can you instance any other forms?

Draw plans of some half-dozen flowers, giving positions and numbers of stamens, &c., correctly, and the forms of the petals. State beneath each what plant it is, and the colour of the corolla.

In what respect does a composite differ from a liliaceous flower? Give rough illustrative sketches.

I want to fill some circles of 6 in. diameter with naturalistic treatments. Give a list of twelve garden flowers, bold in character and as varied in colour as possible, that would be suitable for this purpose.

Plants have their flowers made up of many similar parts, as the buttercup; or their halves only are like, as in the pansy. Give five examples of this multi-symmetry, and three examples of the bi-symmetrical arrangement.

Give as careful a sketch as you can of either white bryony, hop, carnation, or pansy. Give botanical facts respecting the plant you select.

Climbing plants support themselves in several ways. Mention some of these ways.

Mention two styles of ornament in which plant growth is introduced in a naturalistic way, and two wherein it is conventionalised.

What plants would you select to illustrate the four seasons by appropriate groups?

Define and illustrate the various forms of inflorescence.

Draw roughly three equilateral triangles having their apices upwards. In each of these place some ornamental treatment of a plant that by its inflorescence, or other cause, seems suited to such a form. State what plants the respective designs are based on.

Leaves are variously arranged on the stem: mention the leading varieties, giving with each the names of two plants whereon it may be seen.

Sketch and name the principal forms of fruit, writing beneath each the name of a plant in which it is found.

Then, again, not to needlessly multiply requirements, I will mention in conclusion but one more, your designer should be a good archæologist. The history of art, plastic, pictorial, architectural, decorative, should be familiar to him in at least its broader divisions. If he does not know the difference even in look between a Greek and a Moorish inscription, between an Egyptian or an Assyrian capital, or cannot identify a dog-tooth or a ball-flower moulding when he sees it, he is wanting in knowledge that it would be most useful for him to possess. In the *Journal* of the Society of Arts for January 7th, 1876, we find the following paragraph:—

EXAMINATIONS IN FINE ARTS APPLIED TO INDUSTRIES.

These examinations are intended to apply to subjects which are not at present to be included in the general Art Examinations of the Science and Art Department, and especially to test a literary knowledge of the decorative arts. Candidates must have taken a second-grade certificate (Art) of the Science and Art Department.

The examination will be held in 1876, on Tuesday, evening, the 25th of April.

Programmes may be had *gratis* on application to the Secretary.

How far this action on the part of the Society was met and rendered successful I have no personal knowledge, but the idea in itself was certainly an excellent one. Since this paragraph was written, the authorities of the Science and Art Department have included this literary knowledge of the decorative arts in the scheme of their examination work.

Lectures on the leading principles and on the past practice of decorative art should form a leading feature in a good technical school. I trust that it may not appear unduly conceited on my part if I append here the syllabus of a course of lectures which I have at various times given, as in no other way, perhaps, can I so well indicate the ground that, in my opinion, such a course should cover. I need, of course, scarcely say that such a series of lectures requires abundant illustration by means of diagrams, blackboard sketches, &c., and the students should be required to make copious notes as the lectures proceed:—

The principle of Fitness in ornamental art, how observed and how broken. Illustrations in nature of the principle of Fitness. Contrast. Repetition and Alternation of forms. Radiation. Variation. Counterchange. Interchange. Simplicity and complexity, how affected by materials at command, cost, scale, available labour, &c. Symmetry. The Kaleidoscope. Illustrations of symmetry in nature and ornamental art. Naturalism and Conventionalism. Conventionalism of free choice, as in Greek; from religious requirements, as in Egyptian; from imperfect means, as in stencilled designs. The use of interlacing. Examples in Celtic, &c. Interpenetration; a feature in German Gothic. Intersection of forms. Use of Architectural forms as materials for ornament, apart from constructive utility. Influence of materials, climate, &c., on form. Use of armour, drapery, &c., in ornament. How far rules are binding in art. Geometry as a principle in design. Reasons for its adoption in tile work, marqueterie, tarsia, &c. Natural geometry, the honey-comb, stem sections, &c. Examples of the circle and other geometrical forms in various styles of ornament. Use of colour in ornament. Opinions of authorities. Harmonies and contrasts of colours. Definitions of hues, tones, tints, and shades. Colour-blindness or Daltonism. The introduction of animal forms in ornament. Less use of animal forms than of floral, the reason of this. Mythological or symbolical application. Great use during the Middle Ages. Mythical forms, the Sphinx, Dragon, Chimæra, Pegasus, Centuar, Sagittarius, Harpy, Cerberus, Siren, Hydra, Griffin, Unicorn, Sea-horse, Triton, Mermaid, Cockatrice, Basilisk, &c. The lion in classic and Christian art, and in heraldry. Lion as a symbol. The horse. Equestrian statues. The dog. The bull. Apis. Remains of Persepolis and Nineveh. Classic myths, as the Cretan bull, the bull and Europa. The ram. The golden fleece. The lamb as a Christian symbol. The stag. The boar. Classic and mediæval symbols. The wolf of Odin and of Rome. The bear, fox, ape, and leopard. The elephant. Ganesa. The eagle in classic and mediæval art, and as a symbol. The vulture and hawk. The pelican as a symbol in stained glass, &c. The swan. Greek and Roman coinage. The cock. The peacock. The dove, owl, raven, and stork. The ibis of Egypt. Dagon the fish-god. The dolphin. Fish in Japanese art. Serpent worship. The serpent in symbolism and heraldry. The tortoise and lizard. The bee, butterfly, and beetle. Origin of symbolism. Symbolism of action, language, number, colour, and form. The nimbus. The vesica piscis. The sacred monagram. The cross. Symbols of the Passion. Classic symbols, as the thunderbolt, trident, &c. The anchor, lamp, crown, palm-branch, vine, and lily. The Assyrian sacred tree. The Egyptian lotus. The use of the human and angelic forms in symbolism. Mediæval representations of the soul of man and of the last judgment. Heraldry, its meaning and use. Rolls of arms. Ancient use of distinctive signs amongst the Jews, Romans, &c. The Crusades, Heraldry in coinage, seals, and deeds. Canting heraldry. Metals, colours, and furs employed, with their distinctive signs. Honourable ordinaries, as the chief, pale, bend, chevron, &c. Heraldic forms originally structural. Subordinaries, pile, quarter, bordure, &c. Diapering. Common charges, lion, eagle, sword, keys, &c. Conventional animals, as wyvern, salamander, &c. Laws of heraldry. Marshalling. Dimidiation. Impalement. Quartering. Agroupment. Crests. Badges. Mottoes. Supporters. Cadency. Marks of augmentation and abatement. Forms of coronet. Mantling. Importance of accurate representations of heraldic forms by the architect, painter and designer. The use of Inscriptions. Influence of material over the form of character employed. Monograms, their construction, examples from bulls, charters and coinage. Ciphers. The history and practice of Illumination. Use of pictures in Greek churches. The Book of Kells. Use of grotesque figures. Julio Clovio. Invention of printing. Early block-books. Branch letters. Ribbon letters. Naturalistic borders. Decay of Illumination. Destruction of books by the Danes, at the Reformation, and during the Civil Wars. Art processes. Mosaic. Origin in the East. Egyptian Mosaic. The opus figlinum, tessalatum, vermiculatum, &c. Mosaics at Ravenna. Glass tesselation. Golden grounds in Byzantine work. The value of mosaics in the history of art. Tarsiatura and marqueterie. Buhl-work. Parqueterie. Tempera painting, its nature and working. Encaustic painting. Fresco. The Greek pigments. The necessary limitations of fresco-painting. Buon-fresco and fresco-secco. Enamels, incrusted, translucid, and painted. Cloisonné and champlevé. The enamels of Limoges. Grisaille. The works of Limousin. The enamels of Luca della Robbia. Terra cotta. Majolica. Palissy ware. Stained and painted glass. The stone age. Bronze and iron work. Egyptian, Chinese, Japanese, and Greek bronzes. Working in the precious metals. Egyptian and Greek jewellery. Reliquaries. The work of Cellini. Tapestry. The cartoons of Raphael. Gobelins. Embroidery. Wood-carving. The work of Grinling Gibbons. Leather-work. Furniture. Ancient and mediæval works in ivory; pastoral staves, diptychs, caskets, &c. Styles of ornament. Ancient art. Egypt. The tombs, temples, obelisks, and pyramids. Zigzag, wave-scroll, winged-globe, fret, &c. Egyptian influence in Assyria and India. Persepolis. The guilloche. Nineveh. Greek art, the echinus, volute, acanthus, authemion, &c. Greek pottery. Chryselephantine sculpture. The florid character of Roman work. The remains of Pompeii. Mediæval art. Byzantine and Romanesque. Norman and Gothic. The zigzag, cable, dog-tooth, ball-flower, Tudor rose, &c. The Renaissance, Trecento. Quattrocento, Cinquecento. Elizabethan. Strap and cartouche forms. Louis Quatorze, Louis Quinze. Rococo. Mohammedan eastern art. Moorish. Persian. Indian. Chinese and Japanese. Modern work.

The designer may probably never be called upon for designs of Egyptian or Assyrian character, for all the associations connected with the life and religion and habits of these early people are foreign to our time, and gorgeous as such decorations must have been in the clear sunlight by the banks of the sacred Nile, or of the swiftly flowing Euphrates, they are not available for modern use :—

> " The past is but a gorgeous dream,
> And time glides by us like a stream,
> While musing on thy story,
> And sorrow prompts a deep alas !
> That, like a pageant, thus should pass
> To wreck all human glory."

Art at second-hand is already art in its decay; art that is unreal goes the way of all other shams, and the history of art affords us more than one example of this. Greek art was as noble in its simplicity as any that the world has ever seen ; while Roman art, inferior as it was, had yet a certain virile strength; but the debased Græco-Roman is feeble, unreal, hastening to its fall. Hence each healthy period of art has asserted its own individuality. It would appear then, at first sight, may be, that the study of the art of former days, whether Greek, Moorish, or Gothic, can have little value to us in the 19th century, but this is a most narrow and mistaken view to take, as most valuable lessons may be learnt from the varied experiences of the great army of art workers who have gone before us ; general principles may be formulated, and beauties set before us, not to be basely copied, but as spurs to emulation, and guides to success, or faults and failures to warn us from like errors.

Some of my hearers may possibly think that I am raising an ideal standard, but so far am I from thinking this myself, that, did time and your patience permit, I could easily indicate much more that, in my judgment, the fully competent teacher should possess. I should be glad here to turn to the French *Journal Officiel* of the 18th of July, 1881, and bring before you the requirements for the " Certificat d'Aptitude a l'Enseignement du dessin," laid down by the Minister of Public Instruction and of the Fine Arts, as I think the details are somewhat instructive. Two degrees of certificate are given, a lower and a higher. In the first of these, the candidate is required to place in correct perspective geometrical solids, vases, &c., to make a shaded drawing of an object placed before him, and also to give its plan, elevation, and section ; also, to make a drawing of a piece of relief ornament, and of a figure from the antique. He is then required to pass an oral examination in the principles of perspective, and the laws governing the projection of shadows, and, on the strength of casts placed before him, to point out their epochs, and to show his knowledge of the principal points in the history of architecture. After this, he is called upon to answer divers questions on the structure and properties of the human body ; and, finally, a set of faulty drawings is placed before him, and he is required to give oral explanations, as if to a student before him, of the errors he sees in these drawings, and, both by means of a blackboard and by corrections on the drawings themselves, to rectify the faults they contain. The higher certificate is much more searching, and includes working from the life, &c., but it is needless to give details of this, as what I wanted to bring forward in mentioning the matter at all was, to show what was the very least which was held passable by our neighbours. The following is the programme given as a guide for those who are going in for the lower certificate of aptitude for teaching drawing at all :—

Perspective.

I. Définition de la perspective.—Angle optique.—Horizon.—Tableau.—Point de fuite principal.—Points de distance.—Réduction des points de distance. Perspective des lignes horizontales : perpendiculaires au plan du tableau ;—parallèles au plan du tableau ;—formant avec le tableau un angle de 45°.

Perspective de figures géométriques situées dans un plan horizontal et dont les côtés sont perpendiculaires ou parallèles au plan du tableau.—Polygones

réguliers et compartiments géométriques.—Perspective du cercle.

II. Points de fuite accidentels situés sur la ligne d'horizon.

Perspective des lignes horizontales formant un angle quelconque avec le plan du tableau.

Polygones irréguliers situés dans un plan horizontal.

Division des lignes horizontales.

III. Perspective des hauteurs.—Mise en perspective de lignes verticales inégalement éloignées du tableau.

Objets usuels, solides géométriques et fragments d'architecture dont les faces sont perpendiculaires ou parallèles au plan du tableau (vues de front).—Vases, balustres.

Perspective de solides géométriques et de fragments d'architecture dont les faces principales forment un angle quelconque avec le tableau (vues obliques).

IV. Points de fuite accidentels situés au-dessus ou au-dessous de la ligne d'horizon.

Solides géométriques placés sur des plans inclinés.

Division des lignes situées dans un plan formant un angle quelconque avec le plan du tableau.

Ombres.

Déterminer les ombres propres de solides géométriques—d'objets usuels.

Déterminer les ombres portées par ces corps les uns sur les autres et sur les surfaces qui les environnent, le soleil étant au delà ou en deçà du plan du tableau;—dans le plan du tableau.

RELEVÉ GÉOMÉTRAL.

Principes de relevé géométral.—Projection des corps. — Plan.—Coupe. — Elévation.—Relevé d'un fragment d'architecture. — Représentation d'ornements tracés sur des surfaces courbes.

OMBRES GÉOMÉTRALES.

Généralités.—Ombres propres. — Ombres portées. Méthodes générales de recherche des ombres.—Principes généraux.—Conventions.—Rayon à 45°.—Cube de lumière.

Déterminer les ombres propres et les ombres portées de solides géométriques et d'un fragmen d'architecture.

ANATOMIE.

I. Principales divisions du squelette; désignation des parties osseuses sensibles à travers la peau.

Du thorax.

Du bassin.

Du membre supérieur: clavicule et omoplate, humérus, os de l'avant-bras, main en général.

Du membre inférieur fémur, sailles articulaires du genou, tibia et péroné, pied en général.

Du crâne et de la face.

Ee la mâchoire inférieure.

II. Musculature superficielle.

Du dos. (Trapèze et grand dorsal).

De la face antérieure du cou (sternocléidomastoïdien), du thorax (grand pectoral), de l'abdomen (grand droit).

Muscles superficiels des membres et plus spécialement; pour l'épaule, le deltoïde.

Pour le bras: biceps, triceps.

Pour l'avant-bras et la main: long supinateur, fléchisseurs extenseurs.

Pour la hanche: le grand fessier.

Pour la cuisse: couturier, triceps.

Pour la jambe: les jumeaux, le jambier antérieur, les péroniers.

III. Des proportions du corps:

De la tête comme commune mesure.

Proportions des hanches et des épaules dans les deux sexes.

Proportions des parties de la tête.

HISTOIRE DE L'ART.

Antiquité.

Egypte.—Caractères généraux de l'architecture et de la sculpture égyptiennes.

Ornementation des temples.

Grèce.—Constructions cyclopéennes et pélasgiques; examples dans la Grèce proprement dite.

Dispositions des temples.

Explications sur les ordres dorique, ionique et corinthien; monuments de la Grèce, de la Grande Grèce et de la Sicile, encore subsistants, où ces ordres ont été employés.

Désignation des principales moulures et de leurs ornements.

Décorations des frontons et des entablements. Ornementation des stèles.

Vases.—Céramique.

Œuvres principales de la sculpture grecque arrivées jusqu'à nous. Noms des principaux artistes.

Italie.—Origine de l'art romain.

Explications sur l'ordre toscan; exemples de son emploi dans l'antiquité.

Explications sur l'ordre corinthien; en indiquer les plus belles applications sur des monuments antiques subsistants.

Interrogations sur les édifices de style exclusivement romain, situés en Italie et dans le midi de la France.

Ornementation des frises et des moulures.

Bas-empire, époques mérovingienne et carlovingienne.

Italie, empire d'Orient et France.—Origine et disposition primitive de la basilique chrétienne. Ordonnance des monuments religieux de style byzantin; leur ornementation.

Moyen âge.

France.—Indiquer la disposition général d'une église, romane; exemples pris en France.

Ornements propres au style roman.

Préciser le caractère du style ogival.

Plan d'une cathédrale française.

Ornementation des édifices de style ogival; où est-elle le plus souvent puisée ?

Citer les plus beaux monuments de l'architecture ogivale: églises, palais, demeures féodales.

Citer les noms des architectes connus de cette période.

Temps modernes.

France.—Caractères de l'ornementation sous la Renaissance; exemples à l'appui.

Quelles modifications subit l'architecture française au XVIIe siècle; quelles modifications au siècle suivant ?

Exemples.

Nommer les plus grand artistes français des XVIe, XVIIe et XVIIIe siècles. Préciser leurs œuvres.

This, I must be again allowed to impress upon you, is not the sort of certificate that is suggested for special technical teaching, but represents the minimum of art knowledge that any one who wishes to undertake art teaching at all in France is required to possess. It is interesting in that it illustrates the emphasis that the French give to two very definite aims—features in which they as yet certainly excel us—a thorough knowledge of decorative design, and the power of drawing the figure.

Turning, however, from the general to the particular, I would desire to indicate my own ideas as to how the art teaching of our schools may be made to contribute to the valuable movement for technical art instruction that has sprung up amongst us. It will have been already gathered from what I have said that I am not by any means prepared to admit that the Kensington system is a failure, but at the same time it is the tendency of almost everything to fall into a groove, and to rest there in happy contentment while time is all the while moving on, and bringing fresh light and fresh experience in its train.

Freehand drawing proves in all our schools the natural starting point. All drawing is either done by means of instruments or by the hand alone, so that a drawing from the antique or the life falls naturally into this second class, but the term freehand is more ordinarily limited to the drawing in outline of forms of flowing curve, and more or less decorative character. The discipline is a very excellent one, but in my own practice I always endeavour, after a little while, to introduce it alternately with model drawing. When weariness sets in, interest and profit end, though we must not listen to the impatient remarks of those who kick against this discipline all the while we feel that the training is doing them good. We are sadly in want, I think, of a good set of freehand examples, bold and clear in form, pure in line, and on a larger scale than those ordinarily in use. Most of the examples are too small and fine in detail, and are not the best preparatives for the bolder kind of drawing that will be called for in practical work. It would be well too if they could teach something instead of being merely arbitrary forms. Would not a pupil be more interested if he found that the example before him was an anthemion pattern from a Greek vase, a spray of lotus from an Egyptian temple, or an acanthus capital from some pure classic source? In the same way I have often brightened my students' interest, and made the work more real to them, by giving them some such thing as a design on a book cover, for example, to copy and enlarge for me.

It would be eminently desirable if some kind of censorship could be exercised on the various examples so freely produced by enterprising firms. Travellers and agents call on the poor national schoolmasters or other teachers and worry them into purchasing sets, in their ignorance of what is really good, that are by no means suitable or good in style. A very common mistake is found in many sets of freehand examples; the designer has drawn his original sketches for publication by means of ruler and compasses, but what he has thus found so easy to produce is much more difficult than he at all realises when it has to be reproduced by children to whom these mechanical aids are forbidden. The five-barred gate, or palings, or Greek fret, or rosette, or geometric pattern made up of arcs of circles, ordinarily appear a good deal too soon in the course for those who have to draw them without the aid of those instruments that make their formation so easy.

For elementary work, Heywood, of Manchester, has hit upon the happy idea of publishing copy-books that combine the ordinary writing examples with alternate pages of simple copies for drawing, so that the child one day writes "jealously, jeopardy, juvenile," or "question, quantity, qualified," in their allotted spaces, and at another time, overleaf, finds in freehand a sheet of geometrical problems or a simple figure to be drawn to scale awaiting him. Messrs. Cassell, in their little sixpenny book, "How to Draw Floral and Ornamental Forms," have hit upon a very happy combination, as not only do we get therein the ordinary freehand type of thing, but also a good many sketches of a more naturalistic character, such as the leaves of the ground ivy, or sprays of the marsh marigold, ivy, or honeysuckle. The idea is so good and the drawings are most of them so well adapted to the purpose, that it seems a pity that a little more care should not in some cases have been taken. When a plant is drawn in a definitely naturalistic way, the facts of nature should not be violated, yet the speedwell flower is drawn with four equal and similar lobes instead of the beautiful variety in form and size seen in the natural flower, and the anemone is twice drawn with its leaves in pairs instead of the invariable three. The book of the same firm on "Elementary Forms and Models" is very good, and of equally practical use.

The well known Vere Foster series deserves entire commendation. The "elementary" book is just what is required. As thirty-five out of the forty-five examples in the "ornament" book were supplied by myself, I naturally feel a little more diffidence in declaring that that too is just what is required, but as I naturally endeavoured to meet that ideal in my own works, I am glad to learn that the book has met general acceptance. Another book that I for the same reason hesitate to mention is my "Marlborough Freehand Drawing Course," though as I have in that endeavoured to avoid what, as a practical teacher, I have felt to be blemishes in other sets, I may at least refer to it as an exemplar of my own ideas, right or wrong, of what such a series should be.

Much of the valuable discipline of this freehand drawing is found in the necessity of getting absolute balance of the parts, and proper proportion of the masses, and the student must never be allowed to count his drawing finished until these essential points are mastered. The final clear outline is a good enough thing in its way, though I think we are apt, perhaps, to attribute over much virtue to a fineness of line that men engaged all day in manual labour cannot possibly reach; but when this is gained at the expense of truth, one feels remorseless. So often one finds a student saying, when errors are pointed out, "I have lined it in now," as though the time for criticism were gone by, and the past irrevocable. It may seem hard to him to indicate by a few bold touches that utterly ruin the delicate outline, the salient faults, but if one does not do it one is false to one's duty. Rugged truth is worth far more than the most plausible sham. Drawing is not chiefly the education of the hand, but of the eye, and when that is trained the other will follow. I find it, too, very advantageous to sit down with my pupils, and, starting with a central line, draw the whole of either the left or the right side of some decorative arrangement that occurs to me, and then require them to complete the balance by drawing the remaining side. They thus see an original form grow before their eyes, and they find a freshness in it that is wanting in an example which they have turned over every day for weeks. They see, too, how to set about such a task, how the leading lines appear first, how the subordinate curves grow from these, and then, finally, how the details fall into their places. I have often horrified my students at the completion of the work by saying, "Yes, very good, but at least half the credit of that belongs to me; now draw another upright line, and design something yourself this time." In vain they protest that they know nothing of designing, and never did such a thing in their lives; if you are inexorable, they presently commence, and when they have once put their ideas into shape on the paper, it gives one an excellent opportunity of pointing out faults that must next time be avoided, and often of giving a commendation that encourages them mightily for effort No. 2. All drawings, I think, should be drawn to a larger or smaller scale than the example, and that not simply in a vague and haphazard way, but by definite intention and within fixed points. I do not, therefore, merely say "draw it larger," but I indicate two points on the paper, and require it to be just so much larger as those limits require. The work should be as evidently practical as possible; if I were appointed to a great machine-making centre, I would draw out a series of examples of saws, brackets, and the like; for if a man can draw the implements about him, and give, for instance, freehand, all the true curves of the saw handle, the taper of its blade, and the set of its teeth, he has surely acquired a possession that cannot fail to be of use to him; while in a great pottery district our examples should give all of beauty and of grace that search amongst the finest vases of antiquity could reveal to us. In early examples, at least of this kind, the forms should be treated flatly. Beginners would only copy the perspective blindly, and without knowing why you had made the curve of your saucer so much fuller than that of your cup, and you will soon put them in any case to model drawing, where all this can be so much better explained, and where they simply must understand it before they can do anything at all.

Model drawing is a most essential feature in art-education, and its practice can hardly be too emphatically advocated. The groups drawn from should not always be placed on the same level; it is often convenient to place them on a similar table to that on which the students are working, but they should sometimes be raised considerably above the level of the eye, and at others placed nearly or quite on the floor. The ordinary solids, the cube, cone, cylinder, and so forth, are clear and bold in form, but it is well to vary the groups, and make them more interesting to beginners by the introduction of other objects better known to them. Thus a desk is as good practice as a cube, a roll of paper or a marmalade pot make excellent cylinders, and a book stood open is a capital triangular prism. As the groups become somewhat more elaborate it is, I think, an excellent practice to point the students to the shelf of models, and ask them to put up a group for themselves; one is often able thus to give little hints on composition, balance, and so forth, that are useful. As soon as a reasonable proficiency is attained in the outline drawing of such groups, light and shade may be entered upon, the medium employed being either chalk or sepia. The student should not be allowed to modify the light and shade at all, but must be required to copy exactly what he sees, the reasons for reflected lights and so forth being explained to him. At this stage his drawing should have no hard outline, but the forms, as in nature, should be defined from each other by differences of tone and shade.

Simple studies of fruit, vases, drapery, and other objects admitting colour will gradually succeed the earlier groups, and these should be worked both in water colour and in oil; and here again the student may very advantageously be required to set up his own group, as he will learn much as to the arrangement of masses, juxtaposition of colours, the fall of the folds of drapery, and so forth, that will be a very legitimate part of his art education. People, unfortunately, will not place themselves in full faith in the hands of the master. I only recently had some pupils who lived in a fine old country house, and who wanted to know how to sketch from nature, and nothing would satisfy them but to begin at the end. I wanted to show them, by a little preliminary model drawing, the principles of perspective, and so forth, but they simply would not have it. If we go to our solicitor, we take his advice, and do not expect him to learn law from us; and if we go to our doctor, we do not prescribe our own medicine; but many a student comes to his master, not to learn, but to teach, or possibly, after a while, brings you the message that was brought to me one evening last week, that "father does not want me to go on with model drawing, I am to do landscape."

Another most valuable study is plane geometrical drawing. The first thing, having got a good box of instruments (nothing being dearer than a cheap set), is to learn the possibilities and the best methods of manipulation. So important did I deem this, that I prepared a little manual entitled "Mathematical Instruments, and how to use them;" and I am glad to know from various sources that it has met a want. Thousands of persons, for example, have figured scales in their boxes, without knowing at all their value, getting no more out of them than, perhaps, their use as a straight edge to rule by, or possibly going so far as to find out which are the inches upon them. Most geometry books, I fancy, err through giving the student too many problems, and by presenting them as a series of isolated facts to be digested independently of each other. Apart from the mental discipline, the effort of memory, and the manual dexterity gained, many problems often found in these books might very well be dispensed with, because practically they are roundabout ways of doing what the T-square and set-square will do much more expeditiously, so that—although it may appear heresy to say so—there is, I believe, still room for a book for busy artisans, to be called the "Common-sense Geometry," leaving out all kinds of useless and fancy constructions, and giving only the most useful problems, and those again in the most direct way. There are, however, two directions in which the work may very advantageously be taken considerably farther than has been done in the past—one being the reduction of various figures into similar areas, and the other, abundant practice in working figures to various scales. My audience will, no doubt, be well aware that the Science and Art Department conducts annually an examination in art in elementary schools, and a year or two ago, or, to be as precise as the subject suggests, on August 9th, 1883, the authorities at the head of affairs determined to include drawing to scale amongst the subjects to be examined, the children being required to draw a plan on squared paper from a sketch, having its dimensions figured upon it, and to enlarge or reduce plane figures to a required scale. From the unavoidable circumstances of the case, the work is necessarily of a very elementary character, but, so far as it goes, there can be no doubt but that it is a valuable addition to the modest programme possible in such schools.

In my own practice, I often find it a very good plan to either prepare a diagram, or make a large drawing on the black-board, of some familiar object, as a door, sign-post, water-trough, or the like, figuring the dimensions upon it, and then requiring the pupils to re-draw it carefully to some given scale.

It is only natural that students—practical hard-working men, many of them with none too much time to spare—should desire to see, at an early date, some practical use in the work they are set to; and I always find that my students enter into the geometry very much more if we can connect it with objects around them, either by showing them a drawing of a window of geometric tracery, or a bordering of Greek fret pattern, or the like. They should also be encouraged to form simple geometrical patterns, and to note the great variety of form obtainable from very simple elements. In the diagram on the wall I have based four very dissimilar looking forms on the simple elementary fact that the radius of a circle goes just six times round its circumference.* Having made such designs, the students may be invited to colour them; it not only emphasises the forms, but gives them useful experience in colour harmonies. In this second diagram we have a series of fret patterns showing the variety possible on so simple a geometrical basis. Another excellent piece of practice is to show the students the pattern-book of some good tile manufacturer, and then let them work out some few of the many ingenious arrangements of octagons, hexagons, equilateral triangles, &c., that they will find there. They will soon find the necessity of neatness of working, or their patterns will never fit in; and no problem should be passed until it is entirely satisfactorily wrought out.

The rule and compass study of perspective, though of essential value to those who are going in for architecture, is, I think, of not so much practical value, where time is limited, as some other subjects. I think myself that its most useful principles may find their most useful demonstration in a thoroughly good course of model-drawing; though as a piece of mental discipline and practice in neatness of working it is undoubtedly of great value, and it will, I trust, be noted that I do not for a moment deny its intrinsic worth, but only feel that the time it may take up may, in the case of those whose hours be few, be still better employed. It is a subject that I have myself a special weakness for, and there are few things that I love better than to worry out a complex problem to the end; and in the recent examinations throughout the country, over 50 per cent. of my students at the Putney School of Art who took up the subject, got the highest mark possible in it, a per-centage far above the usual average. I mention here matter so personal lest any of my audience should fancy that our throwing the perspective over a bit might arise from our own lack of interest in it. What I really feel is that, given an ordinary artisan, or other man of limited means or time, we would rather give him the power of being able to draw a cylinder, or chair, or prism, or other such object correctly to the eye, by means of a course of model-drawing, than that he should produce it by ruler and compass, board and T-square.

Machine drawing is seldom fully taught, I think, in our schools. It is a special subject outside the ordinary art-master's experience, and it is nothing derogatory to them to say that, in many cases, they do not possess the technical knowledge of the action of the machinery itself in a sufficient degree to enable them to superintend drawings made from it. At the same time much that is profitable can be usefully taught. A second drawback is that the students in our schools have considerable difficulty in getting access to good examples of actual machinery in the schools themselves, and the most that can ordinarily be got are either machines or models of the simplest construction, or else detached screws, cog-wheels, bevels and the like. In our English schools we have hitherto, I think, and other practical teachers I know agree with me, gone in too much for teaching mechanical drawing by carrying the students through a prolonged and disheartening course of orthographic projection, taking as subjects for our plans, elevations, and sections, geometric solids, such as the cube, cone, and cylinder. The students would learn just as much projection and the relation of the planes to each other by drawing in plan and elevation a drum-wheel or a piece of spur-gearing, and the knowledge gained by the actual drawing of these machine details would be something incomparably better. So convinced am I of this myself, that though in my student days I went through a long course of this projection of cones, cylinders, &c., I now never use it, but pass my students at once to the drawing of various forms of wheels, screws, and so forth. One can easily give a student such a drilling in the principle of projection that he shall find presently no difficulty in placing any simple piece of machinery in any conceivable point of view, and when you have done this, you have opened the gates of knowledge to him, and all the rest is but added detail.* All drawings should be made to scale, and all centres of shafting or of wheels first found in skeleton form. As little as possible should be done from flat examples, but a good series of these flat examples is much needed; at least no good set, of progressive difficulty, has come under my observation. Each step, as taken, should be understood, and not only the mere drawing copied, but the action of the parts realised; failing this, a man with no knowledge of Chinese might as well hope to teach himself by copying the quaint characters on a tea chest, as a boy begin at once to draw a locomotive (as he always wants to do) without comprehending the use of the forms before him. Both for architectural and machine drawing a knowledge of the principles of isometrical drawing is very useful, and it is a knowledge very easily gained, and even if it were ten times more difficult one is after all only reminded of the wise man's saying, that should, I think, be inscribed in letters of gold in all technical schools:—"The student should not give himself anxiety to save himself trouble, but should give himself trouble to save himself anxiety,"

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* I am of course aware that this statement is not mathematically correct, but for all practical art purposes the statement holds good.

Architectural drawing is another subject of the greatest value, and here again actual observations and actual measurements are of the first importance. Examples when understood are most useful, but it is entirely useless to attempt to teach from them unless the master is able to expound the meanings of the various lines, and unless the student feels a sufficient interest in the matter to endeavour to realise their significance for himself. Nothing gives so good a notion of construction, and the relation of parts to each other, as actually seeing the things for oneself, either in a building in course of erection, or at least in a good model; it is far more instructive than a long course of drawing from the flat, and should at least, if possible, be combined with it. I have found it a good plan with my own students to require them to measure and lay down on paper to a given scale the plan of the room, marking doorways, windows, fireplace, &c., in which they are at work at the time, and then to this they gradually add the surrounding rooms, staircase, and so forth, until they have an accurate plan of the whole of that floor. Another good plan I have found to be to supply the student with some simple series of plans, and then require him from these to draw out the necessary elevations; anything in fact that will take him out of the dull region of meaningless copying, and compel him to think for himself. The subject will be found to fall very naturally into two very definite heads: the necessary constructive details, and the taste which, added to this, makes the building a pleasure to the eye; the essential work of the plumber, the bricklayer, the carpenter, and then the art of the architect. Without the latter we got too often repellent ugliness and meanness of effect; without the former a possibly taking elevation, plus uneven settlement, cracking walls, and the household down with typhoid fever. In a good technical school, I take it, each of these two great sections should receive full attention. Hence the students should know all about bond, the construction of staircases, partitions, floors, roofs, and the like, and he should no less be instructed in the history of architecture.

I may perhaps here be allowed to insert the syllabus of a series of lectures which I prepared for my students, as it at all events gives in a concise form my idea of what such a course should include.

ARCHITECTURE.—Egyptian. Pyramids, tombs, temples, obelisks, and columns, Karnac, Luxor, Dendera, Philœ. Chaldæan temples, Assyrian remains. Use of the arch. Nineveh, Khorsabad, Kyonjik. Temples of Persepolis and Susa. Lycian remains. Greek: Pelasgic. History and structure of the orders. Doric temples in Greece and Sicily. The temple of Theseus. Ionic order; the temple of

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* The ironworks of Messrs. Krupp at Essen, in Prussia, are, I believe, the largest in the world. There are 8,000 hands employed, and the present Director rose from the position of workman to that of Director. All the Fitters are so skilled in designing that whenever called upon, they can furnish the Director with an accurate drawing of the work upon which they are engaged. The technical education of the apprentices and young workmen is closely attended to.—*Letter of Mr. Samuelson, M.P., Parliamentary Paper*, 28th November, 1867.

Athene at Priene. The Corinthian order: the monument of Lysikrates at Athens. Temples of Pæstum. The Erectheum of the Acropolis. Dimensions of Greek temples. Hypœthral, dipteral, &c. Mode of lighting. Caryatides. Theatres. Tombs. Etruscan and Roman work. Free use of the arch. Composite order. Dome introduced. Pantheon, basilicas, theatres, and baths. Colosseum. Supercolumniation. Triumphal arches and columns. Pompeian remains. Bridges. Aqueducts. Early Christian Churches in Rome. The monuments of Ravenna. Circular churches. Mohammedan Art. The Alhambra, Mosques of Cordova, Damascus, and Cairo. The Giralda of Seville. Persian mosques and tombs. Hindu rock-cut tombs and temples. The Taj-Mahal at Agra. Lombard work: Milan, Piacenza, Verona. Romanesque: Worms, Spires. Byzantine architecture: St. Mark's, Venice; St. Sergius and Sta. Sophia, Constantinople. Russian examples at Kieff, Moscow, &c. Saxon Remains. Norman work. Characteristics of early, decorated, and perpendicular Gothic. Scottish architecture: Elgin, Melrose. The round towers of Ireland. The buildings of Anjou, Auvergne, and Burgundy. Chartres, Rheims, Amiens. Flamboyant tracery. Rose windows. Vaulting. Spires and towers. The typical English and Continental Cathedrals. The Town-halls of the Low Countries. German Gothic: Bonn, Cologne, Strasburg. Scandinavian work. Italy. Tudor work. Renaissance: St. Peter's at Rome; the Louvre. The Glyptothek and Pinakothek at Munich. Modern work.

I need scarcely say that such a course calls for abundant black-board and other illustrations, and the students should be required to make copious notes and sketches. A further inducement to do this may perhaps be found in the offering of a small premium for the best set of notes. Students should also be encouraged (or possibly required would be the better word) to prepare drawings, say on Imperial size paper, illustrative of the subject and thoroughly and carefully worked out. It is so very easy to make a bold free sketch in one's note-book, that after all may not convey a very clear notion to the student of the real facts. Such drawings as I propose then would include, for example, a carefully drawn series, on one sheet, of the five classic orders, or the front and side elevation of one of the more important Greek temples, or a sheet of Norman doorways, or of Gothic window tracery.

I felt myself, that it was so impossible to divorce some consideration of the sister art of sculpture from that of architecture, that I at once found it necessary to prepare a second series of lectures, the syllabus of which also I here append:—

SCULPTURE.—Conventional character of Egyptian work. The Sphinx. Colossal figures. Egyptian mythology. Affinity in art of Nineveh with Egypt. Assyrian mythology. Cuneiform inscriptions. Lions and bulls of Kyonjik. Monuments of Susa and Persepolis. The sculptures of antiquity represented on coins. Shield of Achilles. Golden Jupiter in temple of Belus. Herodotus, Diodorus Siculus, Strabo and Josephus on ancient art. Statues of Memnon at Thebes. Destruction under Cambyses. Greek art. The lion gate of Mycenæ. Bronzes. Greek mythology, Pliny's history of painting and sculpture. Minerva of Phidias. Chryselephantine sculpture. Carving on gems. Venus of Praxiteles. Doryophorus of Polycletus. Dioscobolus of Myron. The remains from Eleusis. The Laocoon. The Niobe and her daughters of Scopas. Etruscan Sculpture. The Elgin marbles. Colour on Greek statues. Drapery treatments, Colossus of the Sun at Rhodes. Metopes of the Parthenon. The Harpy monument. Caryatides. Lycian remains. The tomb of Mausolus. Rome. The Wolf of the Capitol. Arch of Titus. Trajan's Column. Early Christian art: St. Ambrogio, Milan; Sculptures in Christian Museum of the Lateran. Byzantine influence. Ivory carvings; ancient and mediæval. The Ravenna chair. Gothic sculpture in France, Germany, and Britain. The Grotesque. Symbolism. Works of Andrea Pisano. Milan Cathedral. The Campanile of Giotto. Reliefs of Lucca della Robbia. Terra cotta as an art material. Thorwaldsen. Flaxman; his connection with Wedgwood, and designs from Homer, Æschylus, and Dante. Works of Nicholas and John Pisano, at Pisa, Sienna and Orvieto. Works of Donatello and Brunelleschi. Bronze gates of Ghiberti. Peter Vischer and the German school. Michael Angelo. Benvenuto Bellini. Bernini. Canova. Wood carving: Grinling Gibbons. India: Sculptures of Elephanta and Ellora. Japanese work.

I must pass now, in conclusion, to a consideration of the study of decorative design, a study in which, within the lifetime of many of us, we were nationally in an apparently hopeless condition, but in which, within a comparatively narrow limit of time, we have made enormous strides. Our rivals, however, are ever pressing on to higher things, and the position we have already gained is no resting place, but only the starting-point for a renewed departure. Thoughtful men in France, long convinced that their nation was the supreme head in all matters of taste, have at last awakened to the fact that England is pressing closely on them, and thoughtful men in England must spur our own people on to even fresh endeavour. Paul Leroi writes:—"Competition becomes each day more formidable, and the time can be foreseen when we shall no longer be able to cope with it. The statistics of the Ministry of Commerce show that the total of our exports coming within the class of products of artistic manufacture is diminishing most seriously, whilst that of competing nations, and particularly of England, is rising rapidly." Mr. Charles Robert, again, in an official report to the French Government, writes:—"We must insist on pointing out the remarkable progress made by our competitors, and we warmly urge those persons who may be blinded by an exaggerated confidence in the traditional superiority of French workmen, to think of the fate of the hare and the tortoise." Much similar testimony might be produced, to show that our neighbours are wide awake to the struggle between us, while the establishment of art schools everywhere, and technical schools in all our leading centres of industry, are welcome proof that we, too, are alive to the great issues before us. I have been repeatedly asked, "Can design be taught at all? Is it not a natural gift?" I would reply, that undoubtedly some have the gift in a far greater degree than others, but that education develops this gift and makes it manifest where before it had no power of expression. The master cannot teach that which genius alone can supply, but he may give those material aids with which the student can afterwards express what genius dictates.

It will readily be gathered from what I have already said, that I should attach great importance to the study of past art, but I would desire strongly to enter my protest against the idea that past art is necessarily good. Things often find their way into museums on account of their undoubted and quite legitimate archæological interest, or perhaps even, in the case of local museums, because some influential person of the district presented them, and they could not well be refused, and yet from the decorative student's point of view they are hurtful and misleading. It must also be borne in mind that the field of knowledge is so vast, and human life so short, that we must necessarily make a selection, and be content to leave some things untouched, and it then becomes important to make that selection wisely. It is not every semi-barbaric thing that is worth the copying, not every New Zealand club, not every fragment of Mexican or Peruvian pottery, not every bed-quilt or embroidery worked a hundred years or so ago, while some of them are literally, and in all sober earnest, injurious to look upon for beginners. In a technical school museum mere accumulation of specimens should be rigidly guarded against; the empty shelves will gradually get filled, and in the meantime they will do the students far less harm than some of the promiscuous gifts might do. There is perhaps nothing more certain than that if you want your designer to produce beautiful work, you must surround him with beautiful things, and if the outer air be murky with furnace smoke, and all the surroundings squalid and mean, your designer's gift will as infallibly decay within him as the shrubs in the forecourts of the dingy cottages of your workpeople, or the blasted trees that come within the range of your fumes. The continental designer breathes a purer air, enjoys a brighter sunshine, finds in every town a well kept public garden, is surrounded by fine buildings and statuary, and has the run of museums and galleries of works of art that cannot but irresistibly influence him daily and hourly. Much of this, I trust, will yet be possible in the more or less near future for our own people, but until that good time comes, they are at a very definite disadvantage.

In every good technical and other art school the students should have abundant illustrations, not only of the art of the past, but of good contemporary examples. Many of these would be framed, and thus always appealing to the eye, while others may be mounted on sheets in drawers, or pasted in big albums or scrap-books, and always available for use. When such books were once started, both masters and students would gladly bring contributions; but the quality of the work and not the mere thickness of the book must be the prime consideration.

A sketching club is another invaluable institution in a school. The list of subjects should be made out some time in advance, and a small committee of masters and students should work out all details of management, prize fund, and the like. At my own school the drawings are sent in at the beginning of each month, marks are awarded, and at the end of the session book prizes are given. Each student subscribes one shilling the session, and out of this and the fines payable by those who omit to sent in work, the prize fund is formed. Such gatherings of work are most instructive to all.

A conservatory, even if only on the most limited scale, is another most desirable feature. Plants when gathered and brought to the school soon lose their freshness, and it is an immense advantage to have them available in their growing state. The studies of plants required by designers will not ordinarily need that refinement of finish that many flower painters would feel bound to give. What is really wanted is all the vigour and truth of the growth of the plant, and as much as possible of its life history from the opening bud, through the fully expanded blossom, to its ripened fruit. In the last set of drawings sent in for the annual national competition, I remember noticing one of a hollyhock that had been so long in the doing that some foot or so of its head was quite drooping and dying. Whether we regard this as a pictorial study, or as an aid to decoration, it was, I venture to think, equally a mistake. The colour should be dashed in in masses and treated as broadly as possible; elaborate stippling and hatching is entirely out of place in a study of this kind, and it will often be a help either to paint in body colour on a tinted paper, or to add a background to the forms. The studies I here submit to you of the garden poppy, sunflower, and purple iris, are illustrations of the sort of thing that I think is wanted. While one feels the extreme delicacy of appearing to praise one's own work, I would just point out to you that in the limited space at disposal we get several positions of each flower, the tints are put in broadly, and, while the studies are purely naturalistic, their arrangement as panels call for some little decorative plan and balance.

The plant studies of the beginner may, for some little time, be in outline, as he must not be confronted with too many difficulties at once; but as soon as his proficiency in drawing will justify it, he should commence colour, at first in flat local tints, and afterwards as expressive of light and shade. The designer should have a personal knowledge and study of nature; to refer to plates in books is all very well for those who can get nothing better, and who are willing to work second at hand; but it is at best a poor alternative, and no one need hope to excel who is not a persistent student and sketcher from nature. The charming flights of birds on a Japanese plate, every wing a study, and every feather absolutely right in its position and foreshortening, or the graceful undulations of the fishes in the stream below, are drawn by men who have given loving study in the great world of nature, and can be no way producible from the stiff woodcut of some book on natural history, hopelessly turned over by some poor student townsman in England whose knowledge of country life would scarcely enable him to distinguish a heron from a carp.

The earliest designs of our students would naturally be very simple in character, but they should always have a definite intention, and instead of merely filling a hexagon or a circle with some decorative form, an assigned end for the work when done should be present in the mind. The student, too, should not be content, even in the very roughest sketches, to merely outline his forms, but should always work them in colour, as one by this means realises the masses so much better, and many a design that looked richness itself in outline shrinks woefully on the application of colour.

Messrs. Alexander and Shepheard have brought out a series of ornamental examples to a large scale, and printed in flat tints of colour. Some few of these might be advantageously copied by the student to a good bold size and then painted. He would thus get a piece of good practice in drawing, and in the application of large washes of flat colour, and would incidentally learn the value of judging his decorative forms not merely by their outlines but from their masses.

Though floral work is naturally often appropriate where animal forms could not be so well introduced, the designer will do well not to limit his studies too exclusively in this direction, but to enlarge his sympathies not only from the lowly hyssop to the goodly cedar, but to all the works of nature, from the graceful delicacy of form and colour of the little sea shells that we crush unheedingly beneath our feet, up to the study of the human form itself in all its feminine grace or manly vigour.

L. S. D. has too often regarded A. R. T. as utterly unpractical, and Crœsus entrenched in his counting-house has despised the idea of taste, and too long regarded but the manual skill of his hands; but time has shown that heads too have their value in the national output, and that the brawny muscles of hundreds of strong arms make the better account in the ledger, even to put it on this very low but most practical way, when wielded by intelligence and directed by busy brains. Amongst the controlling thinkers room must now be found for the art master and the designer.

The standard of art education is rising rapidly in the country, and drawings that, ten years ago, would have won rewards in the national competition of works held by South Kensington, are now entirely below the required mark. The increased importance given to drawing in the recent regulations for national schools, and its thoroughly practical character, is another distinct national gain. The establishment of such scholarships as that open to students of the West London School of Art, where a student receives a handsome sum to enable him to study decorative design on the Continent, is yet another hopeful sign, while it is impossible to estimate the good wrought by the princely generosity of such men as Sir Joseph Whitworth or Sir Josiah Mason. Five American gentlemen contributed amongst them £63,000, and founded the Technological Institute of Boston, and our own merchant princes are contributing liberally in the establishment of technical schools in the North. I trust that the time will come when every large centre of production will have its well appointed school and museum. The national importance of decorative design has always impressed me, and in my humble way from the publication of my first book, "Plant Form," in 1868, followed by "Plants: their natural growth and natural treatment," in 1874; the "Principles of Ornamental Art," in 1875; "Wood Carving," in 1877; and "Suggestions in Floral Design" in 1880, and other smaller works, I have endeavoured to contribute my mite to the end I had set in view, and I trust that in that good time coming when these special schools shall have been established, some place may be found in them to test these theories in a more extended sphere than my own small school permits. I have necessarily very hastily and imperfectly, in the limited time at my command, set before you my ideas as to what technical art education should include, and I feel that I cannot now do better than sink my own individuality by quoting, in conclusion, the words of a great thinker* in another field of work, but which, nevertheless, are sufficiently appropriate to our purpose to make them well worthy of our consideration:—

> Practice and science must now join together in close alliance, or the former will soon emigrate to other lands. The time is past when practice can go on in the blind and vain confidence of shallow empiricism, severed from science like a tree from its roots. The rudest sailor may steer his ship in the direction of a land-mark, but without compass and sextant he does not traverse the expanse of ocean. Ignorance may walk in the path dimly lighted by advancing knowledge, but she stands in dismay when science passes her and she is unable to follow, like the foolish virgin, having no oil in her lamp. Depend upon it, an empirical knowledge of practice is not the way now to succeed in the struggle of individuals or in the struggle of nations. Intellect is on the stretch to get forward, and the nation which holds not by it will soon be left behind. For a long time practice, standing still in the pride of empiricism, and in the ungrateful forgetfulness of what science has done in its development, reared upon its portal the old and vulgar adage that "an ounce of practice is worth a ton of theory." This wretched inscription acted like a Gorgon's head, and turned to stone the aspirations of science. Believe it not; for a grain of theory, if that be an expression for science, will, when planted, like the mustard seed of Scripture, grow and wax into the greatest of trees.

DISCUSSION.

Mr. E. C. Robins was very glad to find that Mr. Hulme had drawn attention to the importance of studying art from the archæological point of view. Each period had a style peculiar to itself, especially times before the Renaissance, since which people in had got so learned about what every one else had done, that they sometimes made their own style a mixture of all that had gone before. It was most important for young people to learn that many of the forms of art they were accustomed to use were originally peculiar to a certain period; thus in architecture the early English, early Gothic, decorated, perpendicular styles were so different in origin, that it was like using a false quantity in Latin to use a detail belonging to one period in connection with a work belonging to another. That very room was an illustration of something more than mere classic architecture. The building had been erected by Adam, who had a school of his own. When he (Mr. Robins) was honoured by the Council with a commission to design the ornamentation for the room, he made it his business to examine all the details he could find of Adam's particular mode of treatment, and the ceiling was simply a combination of those forms. It would have been a gross error to have designed it otherwise, though it might have been in the classical style. Ancient styles arose naturally out of the wants of the people, who did not then know what was going on in other places, and they proceeded from simple to more and more complex forms. He was pleased to find that, in the case of mechanical drawing, Mr. Hulme advocated drawing from models rather than copying drawings. If this latter plan had to be followed, the same system should be adopted as he had seen at Carlsruhe. There he found the master first gave drawings of each portion of the machine in detail, and then afterwards sketched on the board the complete machine, which the pupils had to reproduce as a finished drawing, with all details worked out. Ornaments derived from flowers should be treated in the same way. Anyone who simply copied one of the drawings exhibited, would never be able to reproduce a similar design without a copy, but if he carefully studied the natural flower he would. Nature was the basis, and should underlie everything in art, and the more this was recognised, the better designs would become. Burges, the architect, was exceedingly clever in drawing the figure, and he used to say that no architect was worth much who could not draw the human figure. Most people would agree that any one who was good at the figure could not be bad at anything else, and he was glad to see that this point had been insisted on.

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* Dr. Lyon Playfair.

Mr. G. N. HOOPER said it was very refreshing to find this system of technical art education brought forward so prominently, at a time when there was so much apathy amongst manufacturers on the subject. Very recently, he was glad to say, the London Chamber of Commerce, having been called upon to reply to a series of questions put by the Royal Commission on Trade Depression, had unanimously passed a resolution stating that a better system of primary and secondary instruction was required, with special provision for the technical instruction of apprentices, workmen, foremen, managers, and employers. This would bring the subject prominently before the Royal Commission, and also, he hoped, before other Chambers of Commerce; and if it were backed up by similar resolutions, especially from localities where art manufactures were carried on, it might induce the Government to give more support to the work, which had already made some progress. Not long ago he saw a passage in a French paper which showed that their neighbours were to some extent alarmed at the progress being made by other nations, it being stated that in Germany there were 10,000 students under technical art instruction. England invited competition from all the world in art products, by her free trade system, and under such conditions it was essential that the most strenuous efforts should be made to enable her to keep her position at the head of manufacturing nations. It was very desirable that students in technical schools should have a certain amount of previous preparation, for if they entered with no knowledge of drawing or geometry, they had a good deal of uphill work before they could really touch the subjects they had to deal with. Voluntary schools could do a great deal by giving the use of their school-rooms in the evenings for lads who had left school. From 13 to 23 was a most important age, when lads just set free, and enjoying their liberty, often got into bad habits, and if evening schools for teaching drawing, mechanics, botany, &c., at low rates were established, it would give them a good preparation for entering technical schools. From a social point of view it was of immense advantage to civilise and instruct these youths, and those who engaged in such work were doing an act of the highest patriotism. Mr. Hulme had referred to a kind of censorship over copies and models being desirable, and if he could devise any scheme by which it could be carried out, he would be doing a great deal of good. He knew of a school at the present moment where the pupils were being taught from models which were bought cheap in a builder's yard. If children were brought up amidst dirty and shabby surroundings, their habits would correspond, but if their surroundings could be improved, and they were taught to admire good drawings and models, their tastes would be elevated, and they would be better able to take advantage of the instruction offered them. In the preservation of antique works, he thought happily there was generally a survival of the fittest, and that bad examples were generally eliminated.

Mr. MILLIS agreed with what had been said about geometry and mechanical drawing, and that a sufficient knowledge of projection could be taught by means of drawing plain elevations of a spur wheel, and similar objects, always supposing that the pupil was going to be an artist, and not a mechanic; in the latter case, something more was required, but it did not come under art teaching. He wished all mechanics who came to learn geometry had a good knowledge of freehand and model drawing, and that would be better than teaching geometry in an art school. It was of great importance also that copies and models for drawing should be selected according to the industry followed in that particular district. In the case of tools, for instance, many of the hand tools now made were almost useless, because the old forms had gone out of use not being preserved in drawings, and those who made them did not understand their use. He thought it would be quite possible in an ordinary art school to give a series of lectures on the principles of design, which would teach sufficient to prevent workmen making articles of any kind in a radically bad form. There must be certain principles which could be easily mastered, without going through a long course of study on design.

Mr. H. CUNYNGHAME cordially agreed with what had been said by Mr. Hooper, as to the importance of providing instruction in the evenings for lads and apprentices. It was perfectly scandalous to see the way in which many of the young men in the East-end of London spent their leisure time. Attempts were being made to form excellent youths' institutes, and anyone interested in the subject could not do better than visit the Polytechnic, conducted by Mr. Quentin Hogg. The great difficulty in the way of technical education was the expense. To teach a boy his whole trade in this way cost about £20 a year, and at the same time he was earning nothing. The result was that, in the majority of cases, the parents were too poor to send them, and the schools fell more or less into the hands of those who could well afford to pay. He found, after some inquiry, that the parents of half the boys in the Technical School in the Rue de la Villette could perfectly well afford to pay for the education of their children, while they were throwing the whole of the expense on the State. However anxious they were to set up technical schools, and however good the work might be on a limited scale, if it were to be done wholesale, the apprentices' work must be supplemented by evening schools. He was very glad to hear the importance of studying nature enforced, for without that it was impossible to design anything well. Students would not do this unless they were compelled. They would bring you something from the last book they had got hold of, but which they did not understand, not having time or opportunity to study archæology. In art teaching there were two sets of pupils to provide for. First, those who had real talent, and in their case you had only to put good examples before them, and all the rest would come naturally. A great master might perhaps mould their style, but the masters who could be provided in quantity could do but little for them. The ordinary boy was the one who could be influenced. The Germans won their battles not so much by genius as by having a set of rules by which ordinary men, if they followed them, could not go very far wrong; and in the same way, whilst clever boys would be sure to get on if they had the best examples before them, ordinary boys should be compelled to study nature, and then the best results possible would be produced.

Mr. G. A. **THRUPP** said he had taken a very practical interest in art education for a long time. He had felt that workmen required some further training, in order that they might put beauty into the objects they had to create, and one of the first things they had to learn was drawing. A somewhat similar scheme to that now described had therefore been set on foot, and several hundred young men had passed through the classes with great advantage to themselves in every way. Only a few weeks ago a young man, simply through the ability he had shown in drawing in these classes, had obtained a very good situation in Calcutta. The West London School of Art, with which he was well acquainted, was one of the most successful. It was found that the students there were attracted in a great degree by the love of art. Many of them were engaged in manual occupations during the day, and they came there at night to improve themselves and to acquire a knowledge of art, and he believed that was the purpose for which these schools were established. It was very important that the study of art should be accompanied by a study of nature, which was sometimes rather difficult in towns; but there were generally prizes offered for sketches from nature to be done during the vacation, and this was a great addition to the mere teaching in the school. It was also very important to make use of Board and voluntary school-rooms for evening teaching, and to make the subject as attractive as possible, not frightening the students by too many hard names.

Mr. **LIGGINS** wished to say a word in favour of freehand drawing, which he was entitled to do, having some fifty years ago taken from the hands of the Archbishop of Canterbury the first prize for drawing which was awarded at King's College. He there had the advantage of receiving instruction from Mr. Cotman and his son, who were very celebrated at that time, and he believed their pencil drawings were still much used as copies. In that very neighbourhood once lived two of the greatest water-colour painters, Girtin, and Turner, his pupil. Turner used to delight in going into the country and sketching, bringing his work back to Dr. Munro, of the Adelphi-terrace, who gave him 5s. each for them. A good deal had been said about drawing from models, but he must take exception to models being used to draw from in the composition of a picture, especially in the case of ships, for it never gave a good result. One of C. Stanfield's large pictures always offended his eyes, and he could not tell what was the matter with it, until one day mentioning it to Mr. E. W. Cooke, he told him it was because the ships were painted from models. He did not see any necessity for models when you had learned to draw, for when the eye was properly trained, it was more difficult to make a mistake than to be accurate. The late Mr. Weedon used to draw admirable sketches of ships for the *Illustrated London News*; but at the present day we had not a good nautical artist, and he would recommend any young man, who had at all a taste that way, to spend a good deal of time on the river amongst the shipping, for he would find a good opening in that direction. The anatomy of a ship could be more easily studied in a day than that of the human body in a month. He was never a figure painter himself, but had always understood that anyone who could draw the human form could draw anything.

Mr. **HOOPER** thought Mr. Cunynghame had rather exaggerated the cost of technical training. They found the cost was from 25s. to 30s. each pupil per session. Of course, the classes were always struggling with financial difficulties, and money could not be better bestowed, either by individuals or public bodies, than in assisting them. The teachers in many cases worked for very small remuneration, depending partly on the grants earned by the pupils. The class he had the honour to be connected with got the use of a parish school, and a grant of £20 a year from a City Company, or they would have been in still greater difficulties. The Architectural Association had lectures and classes, attended by about 1,000 pupils, the charge being 10s. 6d. per session.

The CHAIRMAN, in proposing a vote of thanks to Mr. Hulme, said he did not feel competent to say much about art; but he did not like to let the occasion to pass without some recognition of what had been done by their late friend Sir Henry Cole, and the great interest he took in the promotion of art and science teaching. In 1846, when prizes were offered by the Society of Arts, for the best designs for jugs and tea services, &c., Sir Henry Cole (then Mr.), under the name of Felix Summerly, took some of those prizes. The Exhibition of 1851 was held shortly afterwards, one result of which was the establishment of the Science and Art Department at South Kensington. He must also lay claim on behalf of the Society of Arts to a great share in originating the movement for technical education now going on. The City and Guilds Institute, which had a large branch at South Kensington, was essentially due to the action of the Society in having instituted technological examinations. Why had this institute not taken the position it was entitled to? The fact was, there was no provision made for maintaining an artisan who might wish to come up from the provinces; there was a perfect organisation for his instruction, but none for maintaining him, and until something of this kind was devised, the student from the manufacturing districts, where technical instruction was of so much value, could not come to town to benefit by this institution. They were told that there were 10,000 students in the German technical schools, but he would undertake to say that some provision was made for their maintenance, or they would not be there.

The vote of thanks having been passed,

Mr. HULME, in reply, said with regard to models being purchased cheaply, they might be good, or they might not. In his own school he had a large number of flooring blocks, such as were laid down herringbone fashion in schools; they cost a mere nothing, but with ten or a dozen of them he could form uprights, cross-pieces, steps, door-ways, and a great variety of objects. He agreed to a certain extent that there was a survival of the fittest, but he had instances in his mind of the contrary. Some short time ago he had a number of chromo-lithographs sent him, and probably they were sent to other teachers, amongst which he found a piece of Dutch embroidery, about 150 years old, an old bed quilt, which was quite atrocious. He had carefully put it away out of sight, and hoped it would remain there. It was not always because a thing was published that it was up to the mark. He did not agree that art masters should not teach geometry, for the amount required by an artisan was quite within the reach of an ordinary art master's teaching power. He was for thirteen years art master at Marlborough, where he had charge of boys going up to Sandhurst and Woolwich, where the examinations in geometry were of a much more advanced character than those of the Science and Art Department, and during that time only two of his students failed. When he left, another South Kensington man took his place, and he had no doubt was equally successful. In his time a large amount of orthographic projection used to be done at South Kensington, but in his opinion some plane and solid geometry was sufficient. Some of the speakers had rather wandered from the subject, which was purely technical, not pictorial art teaching. No doubt a few of the pupils came to the school with the idea of becoming artists, but he was not thinking of these at all, but of those who came wishing to turn their art-training to account in connection with their various trades. It was very desirable to give prizes for sketching from nature, and he remembered, when living at Marlborough, a young lady student asking his permission to sketch a fine plant of Indian corn in his garden for one of these competitions. He trusted he could not be accused of failing to recognise what had been done by Sir Henry Cole, for he had clearly stated how much he agreed with a great deal of the South Kensington teaching, and in so doing he was giving the highest honour to Sir Henry Cole. A difficulty had been raised that the Technical Institute in Exhibition-road would never do what it ought until some means were devised for boarding those who wanted to attend, and reference was made to the number of students in Germany; but it was evident that the 10,000 students were not all collected in Berlin; and instead of expecting provincials to come up to London, he thought the institution ought to be extended into the provinces.

Miscellaneous.

COLONIAL AND INDIAN EXHIBITION.

As the object of this Exhibition is to represent the progress and the development of each colony, it has been considered impracticable to call upon the Colonial Governments to comply with any form of classification, as has been custom at previous Exhibitions. Each colony has, therefore, been at liberty to make a classification most suitable to its own requirements.

Careful statistics of the colonies will be prepared, carrying the information to 1885, and this will be arranged in such a clear and readable form as to permit this information to be readily understood by the working classes of this country. Maps and plans of the several colonies, specially prepared for the information of the public, will also be prominently shown in the various courts.

As much interest is taken in this country in the woods of the various colonies, it is is hoped that where cases are requisite for the display of goods, these cases will be made from native woods of the colony, in order that a complete representation of the forest resources of each colony may be practically shown; and it has also been suggested that the building stones and marbles of various colonies should be sent over in the form of pedestals.

As it is thought possible that the various Colonial Governments participating in the Exhibition may desire that a permanent Colonial Museum should be founded in London, it has been suggested that there are strong reasons for showing the adaptability of the products of the colonies generally in as practical a manner as possible; hence it would be desirable that the raw product should be displayed in connection with the manufactured article.

His Royal Highness the Prince of Wales has decided that commemorative medals shall be given to all those taking part in the Exhibition; and he trusts to have the assistance of specialists of known repute who will commence to make, at the opening of the Exhibition, exhaustive reports on the various colonies These reports, issued at an early stage, will take the place of the jury system of previous Exhibitions.

Special arrangements will be provided for the practical illustration, by one special kitchen, of all the frozen meat industries, and of the colonial preserved meats, fish, and vegetables. This department will be carried out by the National Training School of Cookery, under the direction of the Royal Commission itself, in order that the due participation of the various interests concerned may be maintained.

There will also be a colonial fruit and vegetable market, which it is hoped that each Government will make arrangements to supply by monthly shipments. This department will also be superintended by the National Training School of Cookery, under the control of the Royal Commission, who will, in addition, organise an exhibition of colonial wines. Arrangements have been made for utilising the basement of the Royal Albert Hall, which, as in previous years, will form an integral part of the Exhibition.

A limited space will be set apart for the exhibition of living animals from the colonies.

In assuming the control of these various departments, the Royal Commission wishes to afford to the actual producers all the advantages of a fair display in the Exhibition. The interests of the producers as exhibitors are of the first consideration to his Royal Highness; and here it may be mentioned that in these departments, as well as generally throughout the Exhibition, it has been decided that only *bonâ fide* colonists can, through their respective Governments, participate in the Exhibition; it will not, therefore, be possible for the Royal Commission to entertain any applications, upon any pretence whatever, from colonial importers or agents in this country.

The time for the opening of the Exhibition is not yet definitely fixed, but it will be on some day during the first fortnight in May, 1886.

Correspondence.

AUTOMATIC EXTINCTION OF FIRES.

In his recent paper on "Apparatus for the Automatic Extinction of Fires," published in No. 1,723 of the *Journal of the Society of Arts*, Professor S. Thompson refers to the employment of eutectic alloys as material, the melting of which shall cause a waterflow. He says:—"The eutectic alloy which fuses at 70·5° C. was not found to be so tough or to have so sharply defined a melting point as some alloys of slightly higher melting point" (p. 44, col. 1). From the general context, it appears that Professor Thompson's statement is the result of his own experiments. I join issue as to the want of sharpness of definition of the melting points. Indeed the very genesis of an eutectic alloy (in the first tentative experiment; after analysis, it is of course to be made by simple addition) ensures a greater sharpness of definition of melting point than that possessed by any other proportion whatever of the same metals. For in any alloy it is the excess of one constituent, over the amount of it necessary and sufficient to form the eutectic alloy with the whole of the other constituent, which separates out first on cooling, and remains longest solid on heating it. In both cases, an intermediate or pasty state is the result; and this is the case whichever of the metals is in excess of its eutectic amount.

Again, by analogy we should expect eutectic alloys to be as well defined in melting point as are their homologues, the cryo-hydrates. These latter are as well defined in this respect as ice itself.

Finally, and as a matter of fact, the eutectic alloys are characterised by as great a sharpness of definition of melting points as are their constituents themselves.

It will be distinctly understood that I am not here advocating this class of alloys for this especial purpose. I maintain that eutectic alloys are pre-eminent for that very property which Professor Thompson would deny to them.

FREDERICK GUTHRIE.

Science Schools, South Kensington,
Nov. 30, 1885.

MEETINGS OF THE SOCIETY.

ORDINARY MEETINGS.

Wednesday evenings, at 8 o'clock:—

DECEMBER 9.—"The Loadlines of Ships." By Professor FRANCIS ELGAR, LL.D., F.R.S.E., M.Inst.C.E. Sir EDWARD J. REED, K.C.B., F.R.S., will preside.

DECEMBER 16.—"Burmah, Present and Future." By HOLT S. HALLETT.

At the meetings after Christmas the following papers (among others) will be read:—

"The Treatment of Sewage." By Dr. C. MEYMOTT TIDY.

"Calculating Machines." By C. V. BOYS.

"The History and Manufacture of Playing Cards." By GEORGE CLULOW.

"Domestic Electric Lighting." By W. H. PREECE, F.R.S.

"The Scientific Development of the Coal Tar Industry." By Prof. R. MELDOLA, F.C.S.

"The Experiments with Lighthouse Illuminants at the South Foreland." By E. PRICE EDWARDS.

"Machinery in Mines." By HENRY DAVEY.

FOREIGN AND COLONIAL SECTION.

The Meetings of this Section will take place on the following Tuesday evenings, at Eight o'clock:—

January 26; February 16; March 2, 23, April 13; May 18.

APPLIED CHEMISTRY AND PHYSICS SECTION.

The Meetings of this Section will take place on the following Thursday evenings, at Eight o'clock:—

January 28; February 11, 25; March 11; April 8; May 13.

INDIAN SECTION.

The Meetings of this Section will take place on the following Friday evenings, at Eight o'clock:—

January 22; February 19; March 19; April 2; May 7, 21

CANTOR LECTURES.

The First Course will be on "The Microscope." By JOHN MAYALL, Jun.

December 7, 14, 21.

JUVENILE LECTURES.

The Two Juvenile Lectures on "Waves" will be given by PROF. SILVANUS P. THOMPSON, D.SC., on Wednesday evenings, December 30th, 1885, and January 6th, 1886. Special tickets will be issued for these lectures.

MEETINGS FOR THE ENSUING WEEK.

MONDAY, DEC. 7...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. (Cantor Lectures.) Mr. John Mayall, jun., "The Microscope." (Lecture III.)

Farmers' Club, Inns of Court Hotel, Holborn, W.C., 6 p.m. Mr. T. F. Plowman, "Agricultural Societies and their Uses."

Royal Institution, Albemarle-street, W., 5 p.m. General Monthly Meeting.

Engineers, Westminster Town-hall, S.W., 7½ p.m. Mr. Philip S. Justice, "The Dephosphorisation of Iron in the Puddling Furnace."

Chemical Industry (London Section), Burlington-house, W., 8 p.m. Dr. P. F. Frankland, "Some Aspects of Filtration and other Methods of Water Treatment." 2. Dr. F. L. Teed, "Note on the Action of Calcium Carbonate on Solution of Ammonium Chloride."

Surveyors, 12, Great George-street, S.W., 8 p.m. Mr. A. D. Wells, "The Cost of Production and the Value received for our various Farm Crops."

Inventors, 27, Chancery-lane, W.C., 8 p.m. Resumed discussion on the Patent Act, 1883.

Medical, 11, Chandos-street, W., 8½ p.m.

Victoria Institute, Adelphi-terrace, W.C., 8 p.m. Mr. J. Hassell, "The Unreasonableness of Agnosticism."

London Institution, Finsbury-circus, E.C., 5 p.m. Mr. W. Mattieu Williams, "Science Applied to Cookery."

TUESDAY, DEC. 8...Farmers' Club, Inns of Court Hotel, Holborn, W.C., 4 p.m. Annual Meeting.

Medical and Chirurgical, 53, Berners-street, Oxford-street, W., 8½ p.m.

Civil Engineers, 25, Great George-street, S.W., 8 p.m.

Photographic, 5A, Pall-mall East, S.W., 8 p.m.

Anthropological, 4, St. Martin's-place, W.C. 8 p.m.

Colonial Institute, St. James's Banqueting-hall, 69, Regent-street, W., 8 p.m. Mr. Edward Combes, "The Material Progress of New South Wales."

WEDNESDAY, DEC. 9...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. Professor Francis Elgar, LL.D., M.Inst. C.E., "The Loadlines of Ships."

Central Chamber of Agriculture (at the HOUSE OF THE SOCIETY OF ARTS), 11 a.m.

Graphic, University College, W.C., 8 p.m.

Microscopical, King's College, W.C., 8 p.m.

Pharmaceutical, 17, Bloomsbury-square, W.C., 8 p.m.

Royal Literary Fund, 10, John-street, Adelphi, W.C., 3 p.m.

THURSDAY, DEC. 10...Royal, Burlington-house, W., 4 p.m.

Antiquaries, Burlington-house, W., 8½ p.m.

London Institution, Finsbury-circus, E.C., 7 p.m. Mr. Carl Armbruster. "The Musical Dramas of Richard Wagner," with illustrations. (Lecture II.)

Telegraphic Engineers and Electricians, 25, Great George-street, S.W., 8 p.m. Annual General Meeting. 1. Election of officers. 2. Mr. Walter J. Murphy, "A Method of Eliminating the Effects of Earth and Polarisation Currents in Fault Testing." 3. Mr. H. Kingsford, "A Method of Localising a Fault in a Cable by Tests from one end only."

Mathematical, 22, Albermarle-street, W., 8 p.m.

Parkes' Museum of Hygiene, 74A, Margaret street, Regent-street, W., 8 p.m. Mr. Eric S. Bruce, "Health and the Electric Light."

FRIDAY, DEC. 11...Astronomical, Burlington-house, W., 8 p.m. Quekett Microscopical Club, University College, W.C., 8 p.m.

Clinical, 53, Berners-street, W., 8½ p.m.

SATURDAY, DEC. 12...Physical Science Schools, South Kensington, S.W., 3 p.m. Prof. William Ramsay and Mr. Sidney Young, "Some Thermodynamical Relations."

Botanic, Inner Circle, Regent's-park, N.W., 3¾ p.m.

Journal of the Society of Arts.

No. 1,725. Vol. XXXVI.

FRIDAY, DECEMBER 11, 1885.

All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

NOTICES.

JUVENILE LECTURES.

The usual short course of lectures, adapted for a juvenile audience, will be given on Wednesday evenings, December 30th, 1885, and January 6th, 1886, by Professor SYLVANUS P. THOMPSON, on "Waves." The lectures will commence at seven o'clock. A sufficient number of tickets to fill the room will be issued to members in the order in which applications are received, and the issue will then be discontinued. Subject to these conditions, each member is entitled to a ticket admitting two children and one adult. Tickets are now in course of distribution, and members requiring them should apply at once.

CANTOR LECTURES.

On Monday evening, 7th inst., the third lecture of the course on "The Microscope" was delivered by Mr. J. MAYALL, jun. The lecture was illustrated by the exhibition of a large number of modern microscopes, lent by Mr. Frank Crisp, Secretary of the Royal Microscopical Society.

EXHIBITION OF MICROSCOPES.

The Exhibition of Microscopes will remain open during the period of the delivery of Mr. Mayall's Cantor Lectures, daily from 10 to 4 (on Saturdays from 10 till 2). Members can admit their friends to the Exhibition by the use of the tickets supplied for the evening meetings and lectures.

COVERS FOR JOURNAL.

For the convenience of members wishing to bind their volumes of the *Journal*, cloth covers will be supplied post-free for 1s. 6d. each, on application to the Secretary.

Proceedings of the Society.

FOURTH ORDINARY MEETING.

Wednesday, December 9th, 1885; Sir EDWARD J. REED, K.C.B., M.P., F.R.S., in the chair.

The following candidates were proposed for election as members of the Society:—

Christmas, Walter, 3, Mowbray-road, Brondesbury, N.W.
Edmunds, Lewis, D.Sc., LL.B., 1, Garden-court, Temple, E.C.
Gilchrist, Percy Carlyle, Palace-chambers, 9, Bridge-street, Westminster, S.W.
McDaniel, J. J., Woodlands, Bandon, co. Cork, Ireland.
Nicole, Henry James, Williams-terrace, Chiswick.
Rockstro, W. S., Elm-court, Babbacombe, Torquay.
Vernon, John, 36, Coleman-street, E.C.
Walker, Edward Lake, 22, Great Cumberland-pl.., W

The following candidates were balloted for and duly elected members of the Society:—

Colbeck, James, Cork Literary and Scientific Society, Royal Cork Institution, Cork.
Crouch, Henry, 66, Barbican, E.C.
Crowdy, James, 28, Craven-hill-gardens, Hyde-park, W.
Denton, Charles Lord, Orielton, St. Briavels, near Coleford, Gloucestershire.
Glasgow, David, 20, Myddelton-square, E.C.
Hopkinson, James, 95, New Bond-street, W, and Ardlethen, West Heath-road, Hampstead, N.W.
Platt, S. R., Werneth-park, Oldham.
Spurrell, Flaxman, L.R.C.P. Edin., F.R.C.S. Eng., Belvedere, Kent.
Squance, Harry, South Moor, Sunderland.
Squance, Thomas Coke, M.D., 4, Beauclerc-terrace, Sunderland.

The paper read was—

THE LOADLINES OF SHIPS.

By PROF. FRANCIS ELGAR, LL.D., M.INST. C.E.

The Loadlines of Ships is not a subject which I voluntarily selected for bringing before this Society, but having been honoured with an invitation from the Council to read a paper upon it, I did not think it right to decline. It is in response to that invitation that I now appear before you.

All persons connected with shipping, or who take an interest in the safety of life at sea, are only too well aware that of all the questions relating to the seaworthiness of ships which have been recently discussed, none caused greater differences of opinion, or appeared more hopeless of settlement, than that of limiting the depth of loading. Charges of overloading have been made against shipowners which reflect not only against their wisdom and prudence but upon their morality, and these have quite naturally been bitterly resented. A state of feeling thus grew up which, for a time, appeared to make reasonable and temperate discussion of the subject almost impossible, and to prevent anything like a frank mutual interchange of views and a reconciliation of differences taking place. It is most unfortunate that a question of such vital importance to the safety of human life upon the one hand, and to the continued prosperity of the British mercantile marine against the growing competition of foreign vessels upon the other hand, should have been so much and so long exposed to the influence of popular prejudice and sentiment; and it is with a belief that we have reached a time when a calmer and a more generous and philosophic spirit is beginning to prevail in the matter, that I venture to offer the following remarks.

The fixing of the maximum depth of loading of ships is by no means a modern idea. Going back to the Middle Ages, we find that in the Italian republics, where marine insurance was extensively carried on, the depth beyond which each vessel should not be loaded was regulated by law.* The loadlines of British ships were similarly regulated, to some extent, from a very early period. The first enactment upon the subject of tonnage that we have any knowledge of, is dated the 9th year of Henry V., A.D. 1422, and it contains these words:—"That keels that carry coals at Newcastle shall be measured and marked." Judging from subsequent enactments, the marking thus ordered was the load-draught of water, or the draught when loaded with the amount of dead-weight which was held to constitute the tonnage. The marking denoted the loadline, and the deadweight of cargo carried at that line, constituted the tonnage. Mr. Moorsom gives an extract from an Act of 15 Charles II., 1661, which reads as follows:—"That Commissioners should from time to time be appointed by his Majesty, his heirs, and successors, for admeasuring and marking all and every the keels and other boats," &c., "to be used for the carriage of coals in the port of Newcastle, and all other places within the counties of Northumberland and Durham."*

It was further enacted by 6 and 7 William and Mary, 1694, that "the said admeasurement shall be by a dead-weight of lead or iron, or otherwise, as shall seem meet to the said Commissioners, allowing three and fifty hundredweight to every chaldron of coals," &c., "and cause the said keels and boats so admeasured to be marked and nailed on each side of the stem and stern and midships thereof," &c. This method of admeasuring keels (limited at first by the foregoing Act to the ports of Northumberland and Durham) was afterwards extended to vessels in loading coals at "all other ports of Great Britain." The vessels, as before, to "be admeasured by a dead-weight of lead or iron, allowing twenty hundredweight avoirdupois to the ton, and marked and nailed as aforesaid to denote what quantity of coals each will carry up to the mark so set thereon."

The tonnage of vessels in early times thus appears to have been often measured by the amount of weight that could be carried between the light- and the load-water lines, with an exception that was made in 1719, in favour of vessels employed in carrying brandy or spirits. It was necessary, of course, to fix the loadline before the tonnage could be determined; and, therefore, the fixing of loadlines must have formed one of the duties of the Commissioners appointed "for the admeasuring and marking of vessels." As the vessels of that day were small in size, and simple as well as comparatively uniform in type, it is most probable that the rule adopted for regulating their load-draughts was of the form that has survived till the present time in connection with certain classes of sailing vessels; viz., a given number of inches of freeboard per foot of depth of hold.

The first general rule "for the admeasurement of ships and vessels in all cases," and that which removed the necessity of fixing the loadline in any vessel not afloat, as a preliminary step to the determination of her tonnage, was enacted in 1773 by Act 13 George III. A further Act, 26 George III., 1786, gave a rule for measuring vessels for tonnage which were afloat, and which could not be measured by the rule contained in the previous one. By this time, therefore, it was unnecessary to fix the loadline of any vessel whatever for tonnage purposes, and the practice of doing so doubtless ceased. It is highly probable, however, that the old practical rule for regulating the load-draughts of ships remained in force among shipowners, and that it was the one, already referred to, of a certain number of inches per foot of depth of hold.

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* "Annals of Lloyd's Register." London: 1884.

* "Minutes of Evidence taken before H.M. Commissioners on Tonnage, 1881." Mr. T. Gray, pp. 1-2, and appendix No. 1, pp. 601-602.

The third oldest known copy of a register of shipping is in the library of Lloyd's Register office, and is dated 1774-75-76. In this book there is a column which contains "the feet of the draught of water when loaded," and a similar column was continued in subsequent register books down to the establishment of Lloyd's Register Society upon its present basis in 1834. It is not known how or by whom the load draught was fixed, and the figures for it are merely stated in round numbers. Probably the load-draught was there noted, not so much for the purpose of strictly defining the limits of loading as to furnish an index to the size of the vessel.

On the institution of Lloyd's Register Society, in 1834, the records of draughts of water were no longer made in the register book, and the load-draughts of vessels not only ceased to be regulated as an element of tonnage, or of any other property they might possess, but also as a useful item of information respecting them. The load-draughts of ships thus became gradually withdrawn from official supervision aud attention.

It does not appear that this inattention to the draughts of water of ships gave rise to any objectionable consequences, so long as ships remained what they were in the early part of the present century. The tonnage rule of 1773, which ultimately superseded the old method of taking the dead-weight carried at a fixed load-draught as the tonnage, and which is known as the "Old Builders' Measurement" rule, caused the forms and proportions of cargo ships to become modified, and to approximate to an uniform type, in which the length was about three and a half times the breadth, and the depth was about three-fourths of the breadth. The floors were very flat, so that the form approached that of an oblong box, which was rounded at the corners and ends. Such vessels had the maximum of carrying power with the minimum of tonnage measurement under the rule. The freeboards given to them were determined by the simple rule of a certain number of inches of freeboard per foot of depth of hold; and such rule appears to have been followed with a fair degree of uniformity, and to have given satisfactory results.

The change from the old rule and practice of tonnage measurement to the present system of making internal capacity the measure of tonnage, removed the inducements just described to build narrow and deep ships with flat floors; and vessels came to be produced which varied materially in proportions and in fineness of form. The comparative uniformity of type which had long existed soon disappeared, and vessels gradually took the dimensions, external shape, height out of water, and erections upon deck, which were considered best adapted for the trades in which they were to be employed. Great diversities of type thus arose; and the safe maximum depth of loading of all classes of vessels became a question which depended in a constantly increasing degree, upon the special characteristics of the various sizes and types of ships. No simple rule of freeboard was any longer applicable, when the safety given by equal heights of freeboard was found to vary materially in different ships, and to be affected by numerous and complex considerations that relate to dissimilar features of construction, deck arrangements, and loading.

This point may be illustrated by a description of the various leading types of cargo carriers that now exist. Cargo-carrying vessels may, first of all, be divided into two classes, viz:—sailing vessels and steamers. Each class includes great varieties of size, proportions, and form; but the greatest differences are to be found in steamers.

Fig 1 (p. 80) shows the simplest type of steamer, viz., a vessel without any erection upon her deck, and whose hull is of full strength throughout from the upper deck downwards. The upper dotted lines in each of the figures represent bulwarks. Fig 2 shows a similar vessel, with a poop and forecastle on the deck. Fig. 3 is the same as Fig. 2, but with a bridge-house in the middle, covering the openings in the deck over the engine and boiler compartment. Fig. 4 shows a vessel with a forecastle, raised quarter-deck, and bridge-house; the two latter being connected. Fig. 5 shows a vessel with forecastle, short full poop, raised quarter-deck, and bridge-house; the three latter being connected. Fig. 6 shows a vessel with a forecastle, long full poop, and bridge-house; the two latter being connected. Fig. 7 shows a vessel in which the deck erections form one continuous structure upon the top of the upper deck proper. When this structure reaches a certain standard of strength, the vessel is called a spar-decked vessel; and when it is of inferior strength, and only comes up to a certain lower standard, she is called an awning-decked vessel. These are the chief varieties of type that are caused by deck erections, although there are other special vessels which do not exactly conform to any of them.

FIG. 1

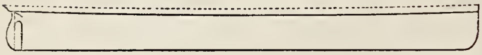


FIG. 2

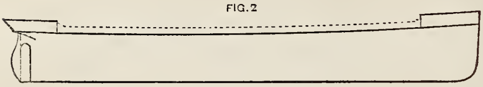


FIG. 3

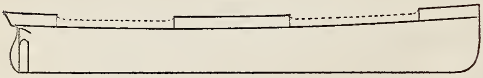


FIG. 4

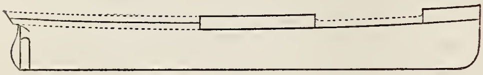


FIG. 5

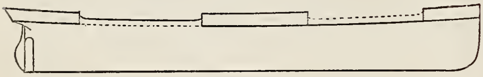


FIG. 6

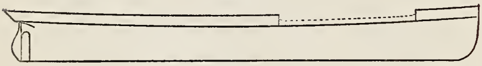
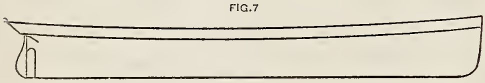


FIG. 7



We thus have a great many different types of ships to deal with at the present day, both among sailing vessels and steamers, instead of the comparatively uniform type of sailing vessel that formerly prevailed; and the deck erections, which constitute the chief element of difference between the various types, have a very important effect upon seaworthiness and upon the height of freeboard that is necessary for safety. It must not be supposed that the diversities of type that are to be found among modern cargo vessels, and particularly among steamers, are the result of mere accident or caprice. They are, as a rule, due to the chief cause of all mechanical improvement, viz., attempts to obtain the best adaptation of means to ends. We are taught that a principle of natural selection operates in the organic world to differentiate beings into species and varieties by means of a struggle for existence, in which slight modifications which in any way favour the individuals of any species by better adapting them to special conditions of life tend to be preserved. So, in the mechanical world, similar results are often obtained by means of the constantly increasing pressure of intellectual and commercial competition. The leading types of ships have been gradually evolved by a process of development, during which innumerable changes have been made; those that have proved to be good, and to be favourable to the special conditions of particular trades, being preserved and added up; and those that have proved to be bad, prejudicial, or useless, being rejected. Thus in one direction we have lightly built river steamers, drawing only one or two feet of water, and with two or three lofty tiers of decks that accommodate large numbers of passengers; and on the other, we have war ships of great draught, which contain nothing but what is necessary to the efficiency of a fighting machine, and which rise out of the water as little as the exigencies of handling them will permit of. Between these extremes are to be found an immense variety of types, each type having been primarily determined by the conditions of the service for which it is intended, and by its special fitness to perform that service.

The present tonnage laws, although they admit, to a large extent, of the changes referred to, arrest development in some directions, and obstruct improvements that would promote safety. Thus there are vessels which, instead of being constructed with a broken line of deck-erections, as in Figs. 4, 5, or 6, might have these erections made continuous, as in Fig. 7, if it were not that the additional space thus included would be measured for tonnage, and the rating upon which all dues are levied upon the vessel would be thereby increased. Many vessels which require a continuous deck at the top of the erections, but in which the space between decks cannot be utilised in carrying passengers or cargo, have such a deck; but large permanent openings are cut in it, right across the ship, in order that the space between decks may not be measured for tonnage. We here have an instance in which improvements that experience has proved to be beneficial are arrested, because of the action of the tonnage laws. It is strange that no means can be devised by which tonnage may be fairly measured, without obstructing improvements that are in the direction of safety.

It is necessary to understand the causes of the differences between the various types of vessels—which are too numerous and complex to discuss fully in this paper—and their exact nature, before attempting to fix maximum depths of loading for them. It must be obvious, that no simple rule of a given number of inches per foot of depth of hold, can now be applied with equal fairness to all vessels alike. Each vessel requires to be judged of separately, and to have its special characteristics adequately appreciated. The problem of framing a general scheme for regulating the freeboards of the principal types of ships involves, firstly, the consideration of how freeboards should vary in vessels belonging to any given type, according to size, proportions, and form; and, secondly, the consideration of how the freeboards of vessels of similar sizes, proportions, and forms, but of different types, should be regulated relatively to each other.

Mr. Martell, the Chief Surveyor of Lloyd's Register Society, has taken the lead in treating the freeboard question in the manner described. He gave evidence upon it before the Royal Commission on Unseaworthy Ships in 1873, and read papers before the Institution of Naval Architects in 1874 and 1882. Lloyd's Register Society issued tables of freeboard in 1882, which were framed by Mr. Martell and his assistants, and which embody the results obtained from a large mass of practical data, collected by Mr. Martell from all available sources of information, during the long time he was working at the subject. The rules and tables submitted by the late Loadline Committee to the President of the Board of Trade are largely based upon Mr. Martell's previous work, and although many others, including officials of the Board of Trade and of the late Liverpool Registry, have worked with great ability and advantage in the same direction, and the Loadline Committee have utilised the labours of all, gratefully and impartially, it is to Mr. Martell, more than to anyone, that the shipping community owe the advance that has recently been made in the position of the loadline question

The Loadline Committee, of which Sir E. J. Reed, K.C.B., M.P., was the chairman, was appointed by Mr. Chamberlain, President of the Board of Trade, at the close of the year 1883. The questions put to the committee were:—

1. Whether it is now practicable to frame any general rules concerning freeboard which will prevent dangerous overloading without unduly interfering with trade.

2. If so, whether any and which of the existing Tables, with any and what alterations, or any other, and what tables should be adopted.

3. How far any such tables can be adopted as fixed rules, and what amount of discretion must be left to the officers who have to see that they are complied with.

The general nature of the reply to these questions, will be seen by the following extract from the unanimous portion of the committee's report:—

1. We are of opinion that it is now practicable to frame general rules concerning freeboard which will prevent dangerous overloading without unduly interfering with trade.

2. We have the pleasure to submit herewith Tables which we consider should be adopted.

3. We are of opinion that these Tables can be adopted, at least for all existing types of cargo vessels and for some years to come, without the exercise of any other discretion on the part of the officers who have to see that they are complied with than that which concerns the quality and condition of the ship. The freeboards assigned by the Tables herewith are suitable for vessels of the highest class in "Lloyd's Register" or of strength equivalent thereto, and should be increased for ships of inferior strength.

To the responsible authorities a large discretion must be allowed, viz., that of applying the Tables themselves with reasonable modifications to any very exceptional vessels which may now exist, or may hereafter be constructed.

For careful as we have been to give full consideration to all actual types and sizes of vessels, we cannot but admit that undue interference with trade might occasionally arise were the Tables to be applied henceforth to all ships, present and future, without any exception whatever. We are well aware that the discretion which we thus regard as necessary is such as should be exercised with very great skill, care, and judgment, but we see no reason why those charged with the responsible duty of preventing the overloading of merchant ships should not have at their command all needful assistance.

The Tables submitted by the committee refer exclusively to cargo-carrying vessels, and the remarks in the present paper are all confined to the same classes of vessels. The committee did not consider the question of differences which may be made in the loading of passenger vessels.

The answers given by the committee to the questions put to them, have made the committee's report an important event in the progress of the loadline question. No representative body of men have ever before succeeded in agreeing upon the fundamental question as to the practicability of framing general rules concerning freeboard which will prevent dangerous overloading without unduly interfering with trade. It must be obvious, however, that the practicability or otherwise of framing such rules depends entirely upon the data of loading, and the extent of knowledge upon all that relates to safe loading that is possessed by those who have to deal with the question. Each shipowner, however large a number of ships he may control, must regulate the loading of his own ships, or must employ some person or persons to do it for him. The problem has necessarily to be dealt with in detail by individual shipowners; and if the knowledge and experience of those who are separately responsible for the loading of the various types of cargo vessels could only be brought together, and general rules framed to embody all the varied experience they possess, nothing more could be desired. The Loadline Committee were fortunate in obtaining from its members, and from the numerous witnesses who gave evidence in London and in the principal out ports, a great amount of data of the class referred to; and as there were upon the committee gentlemen who possessed a varied and extensive knowledge of the loading, of ships they probably had superior advantages to those possessed by others who have attempted to deal with the question.

If the committee have not arrived at so perfect a result upon all points as would have been obtained from the combined knowledge and experience of all the principal persons in the mercantile marine who have to do with the loading of ships—and it cannot be supposed that they have—there is at any rate good reason for hoping that they have, at least, made a very fair first approximation to it. If no more than this has been done, a great step will have been made.

The principles upon which the committee's Tables of freeboard are framed will perhaps be best understood by grouping them under the following heads, viz., 1st, those which regulate the variations of freeboard in vessels of the same type, according to size, proportions, and form; and, 2nd, those which regulate the relative freeboards of ships of different types, that are similar in size, proportions, and form. As deck erections constitute one of the distinctive features of type, they will have to be considered under the latter head.

First, then, as to the influence of size, proportions, and form upon freeboard in vessels of the same type;—and in these remarks steamers only will be considered. In order to provide a starting point for our investigation, we require to select some suitable type of steamer as the standard one, and then to take vessels of the standard type, but of various sizes, that have the same relative dimensions and are similar in form. The type chosen by the committee as the standard one for this purpose is the flush-decked steamer of full scantlings throughout, whose structural strength is not below the requirements of the 100 A class at Lloyd's.

Having fixed upon the standard type of vessel, we next require to select certain relative dimensions and a given form, for the vessels of the type with which to commence the assignment of freeboards. In thus fixing upon a standard of relative dimensions, it has been found that the influence of breadth upon freeboard may be safely ignored in all ordinary vessels; and it is sufficient to regard, in the Tables, only the relation of depth to length. The committee's Tables are therefore framed for steamers of various sizes, all of which are twelve depths in length; and a correction is given at the foot of the Table below each length of vessel, for every 10 ft. of length in excess of, or less than, the twelve depths that are taken in the Tables. The depth taken for this purpose is the moulded depth, and the lengths and depths are measured as described in the explanations of the Tables. The Table given at the end of this paper shows the form in which the various particulars used in computing freeboards are arranged.

The above remarks relate merely to the dimensions and proportions of a vessel. If all vessels, notwithstanding variations in size and relative proportions, were, nevertheless, approximately similar in form, we should not require to go any further, and there would be only one horizontal line of freeboards, or one freeboard for each size of ship in the Table on p. 87. But many cargo steamers are constructed with the fullest possible lines, in order that they may carry the maximum amount of dead-weight, and the question arises of how they are to be treated in relation to vessels of finer forms. This point has probably given rise to more discussion than any other in connection with the loadline question. The view that has found the chief supporters, and which the committee have adopted in their report, is, that when ships of the same size and proportions differ in form, their relative fineness and fulness should be dealt with by leaving above water in each case the same per-centage of the whole external volume of the hull below the upper deck. Thus, starting with vessels of given size and proportions, and of similar forms, or (if we take a coefficient of fineness as being sufficiently representative of form) of equal coefficients of fineness, and ascertaining the amount of out-of-water volume given by freeboards that are proved by experience to be suitable, other vessels of the same size and proportions, but of different coefficients of fineness, will have their freeboards regulated by keeping the same per-centage of total volume above water as a reserve of buoyancy. The committee's Tables have been framed upon this principle to show what the freeboards should be in vessels of varying coefficients of fineness. These freeboards are given in the different horizontal rows of figures in the Table on page 87.

Much has been said, and not without reason, against grouping in one coefficient, as is thus done, the horizontal fineness of the ship, or the fineness of her water-lines, and the vertical fineness, or fineness of her transverse sections. It is, doubtless, the case that, if fineness be carried to an extreme length in either direction, the rule laid down by the committee may require modification, but there is reason for believing that the rule laid down is fairly applicable to all ordinary ships, and that in practice it will be found to work well. It would greatly complicate the question of form to attempt to deal separately with horizontal fineness and vertical fineness, while, at the same time, it must be remembered that there are no established principles to go upon in doing this. The whole difficulty of this question of form is to be found in the fact that no scientific theories ever advanced enable us to calculate the exact influence of form upon safe loading. We know that form has something to do with it, but it is impossible to estimate its effect with absolute precision. All we can do is to lay down an empirical rule respecting form, as we have to do upon other points, that will operate in the direction which we know, by theory and observation, to be the right one, and that will approximately give results that agree with those furnished by experience at sea.

The explanations given with the committee's Tables of freeboard point out that the exact freeboard required for a given ship may thus be calculated by constructing a displacement scale to the height of the deck to which the freeboard is measured, so as to obtain the whole external volume up to the upper surface of that deck. Per-centages of the total volume are given in the Tables for vessels of various types and dimensions, to determine the proportion that must be left out of water.

This method, although practically exact, involves considerable labour, and it has been found that, by using an approximate coefficient of fineness as a measure of form, the variations in freeboard, necessitated by differences of form, may be made to as great a degree of accuracy as is necessary. The coefficient of fineness taken for this purpose, which was proposed by Mr. Martell, is the following:—Divide 100 times the gross registered tonnage below the upper deck by the product of the length, breadth, and depth of hold, and the result will be the "coefficient of fineness for freeboard purposes." This coefficient is not supposed to possess exact scientific value, and it can only be used with advantage by having especial regard to those features of a ship that affect the depth of hold; but it has the great practical merit of being quickly calculated, and of requiring for the purpose of such calculation only the length and such other data as is recorded in Lloyd's Register Book.

The accuracy of this approximate rule was very carefully tested by members of the committee, particularly by Mr. Robert Duncan and Mr. William Denny; and the results satisfied the committee that, when used with intelligence and discretion, and with modifications in certain special cases described in the Report, the coefficient of fineness is all that is practically required in making freeboard calculations. The committee's Tables are therefore framed for the application of this rule, and do not include all the particulars that would be necessary for the separate use of the displacement method. Such additions might readily be made if the displacement method came to be employed in practice; but it is likely that the simpler rule, which appears to be sufficiently exact, and the data for employing which may easily be obtained, will be preferred. The percentages of total volume, which are approximately provided by the freeboards given in the Tables as reserves of buoyancy, are given at the head of each Table.

The Tables are framed so that for a vessel of given size and proportions the freeboards required for co-efficients of fineness, varying from ·68 to ·82, are given in the vertical column that relates to that size.

The complete Tables enable us to fix the freeboard of a flush-decked cargo steamer of any length, varying from 120 ft. to 408 ft., and over, and of any ordinary proportions of breadth and depth to length, and also of any ordinary form. The sheer of deck requires, however, to be taken into account, because vessels with little sheer are much more liable to take seas on board at either end than vessels with large sheer. The Tables, therefore, apply only to vessels of a mean sheer of 20 in. when they are 100 ft. in length; 25 in. when they are 150 ft. in length; and so on, adding 5 in. of mean sheer for each additional 50 ft. of length, till a total length of 400 ft. is reached, when the mean sheer is 50 in. If the sheer of any vessel differs from this standard amount, then the difference between the actual mean sheer and the mean standard sheer is divided by four, and the result in inches is the amount by which the freeboard amidships is to be diminished or increased, according as the sheer is greater or less than that required. The round of the deck is also assumed in the vessels taken in the tables to be one-quarter of an inch for every foot in length of the midship beam. When the round of the deck differs from this, the difference in inches requires to be divided by two, and the result added to or deducted from the freeboard given in the Tables.

We are thus able to deal with flush-decked steamers of various sizes, proportions, forms, sheers, and rounds of beam; but so far we have only considered flush-decked vessels, or vessels which have no houses or erections of any kind on deck. Most steamers have deck erections of some kind, such as are shown in Figs. 2 to 6 (p. 80); and these erections, if strongly and efficiently constructed, add very materially to seaworthiness. Forecastles and poops offer great protection against seas coming in over either end and sweeping the deck; while midship houses, which enclose the openings to the engine and boiler compartments, effectually prevent water finding its way in large quantities through those necessarily vulnerable parts of the deck. The importance of deck erections to seaworthiness will be understood when we remember that, if the deck of a ship could be made as strong and as free from weak places throughout as the outside of the hull, the ship would be watertight and seaworthy however little freeboard she might have. The only thing then left to consider would be a working platform from which she might be navigated with safety. But a ship's deck must necessarily be made with openings in it, whose power of resistance to heavy seas, even when completely closed, is comparatively small. We therefore have to consider two points in fixing freeboards. One is to keep the vulnerable parts of the deck so high above the water that dangerously heavy seas are not likely to break through them; and the other is to provide a platform at such a height as will make the crew safe against being washed overboard. Deck erections are of very great value from both these points of view. Poops and forecastles, as has already been said, protect the decks against being swept fore and aft; and midship houses protect the chief openings in the deck, and those which can be the least effectually closed. When deck erections are carried to the extent shown in Figs. 4, 5 and 6 (p. 80), so that we get what is called a "well-decked" steamer, then, if the vessel be one of a modern type, in which the erections are substantially constructed and closed in at the ends, we have no part of the deck left uncovered, except the short length forward which contains the fore-hatch. These vessels have proved themselves to be very safe at sea. Adverse opinions have been expressed about them at different times, but these are not justified by the records of their performances. No doubt there are well-decked vessels, constructed some years ago, in which the deck erections are of weak construction, particularly at the ends, and are not strong enough to withstand the blows of heavy seas. The essential element of safety in this class of vessel is deck erections which form a continuous part of the structure of the ship, and which are very strongly closed in by iron bulkheads at the ends.

For vessels that are fitted with the different classes of deck erections, deductions are made from the freeboards required by the tables, according to the nature and extent of the erections. The various deductions are described in the preface to the committee's Tables, and it is not necessary to give the details here. All that need be said about them is that the whole question of allowances for deck erections of different kinds is one which cannot be brought within the scope of exact scientific treatment, and it is a point upon which the committee have necessarily been guided more by the opinions of seamen and by the recorded experience of successful shipowners, than by any other considerations. It is one of the points upon which it may reasonably be expected that experience may throw further light, and may show that modifications can be made with advantage.

We have now seen how the freeboards of ships are regulated in flush-decked cargo steamers of various sizes, proportions, forms, and types, and we now come to two other important classes of vessels, shown in Fig. 7 (p. 80), which are known as spar-deck steamers and awning-deck steamers. In dealing with steamers of these classes, which are of weaker construction than those already dealt with, the question of relative strength has to be considered. Flush-decked steamers of the 100 A class in Lloyd's Register, which are of full strength up to the upper deck, are, it is known, amply strong enough to bear loading to the freeboards given in the Tables. Spar and awning deck vessels, which are of less strength, may become unseaworthy through excessive straining action at sea if loaded to the same depths as the vessels above named. And there are instances of vessels of these types having been severely strained at sea, and of some which have probably foundered in consequence, when loaded unduly deep. The principle which the committee has adopted in dealing with these and other vessels that are inferior in strength to those of the 100 A class of full scantling ships in Lloyd's Register, is to fix approximately the limits at which the stresses upon the material of the hull shall not exceed that of the stronger class of the same proportions, form, and moulded depth, when loaded to the freeboard required by the Tables. In our present state of knowledge of how to calculate exactly the relative stresses upon the materials of ship's hulls, it is impossible to rely upon absolute accuracy of comparison, but the principle is a sound one. It can be applied with a fair degree of accuracy in many cases, and it is only to be expected that the present deficiencies in this branch of science will be made good in time. In thus adopting Lloyd's 100 A class as a standard of strength, the Committee must not be supposed to endorse Lloyd's rules in any sense. They are merely taken by the Committee as being the best, or, indeed, the only recognized standard we now have.

This principle of regulating freeboards has been made to apply to 90 A and 80 A vessels, as well as to spar-deck and awning deck vessels; in fact, it has been made to apply to any vessels that are weaker in construction than full scantling ships of the 100 A class. It is possible that many 90 A ships, or even vessels of inferior strength, may be strong enough to load as deeply as a 100 A ship; and doubtless this is usually the case in the smaller class of vessels. But it is probable that if such loading were allowed, the extra cargo that could be carried because of the saving of weight in the 90 A, or a still weaker class of ship, might form an inducement for weaker classes of ships only to be built, and might thus penalise a ship-owner who incurs the extra expense of the 100 A class. The committee were greatly influenced in their decision respecting the reduction of freeboards in vessels of inferior strength, by a desire to remove, as far as possible, any advantage that might be gained by building vessels of classes inferior to the 100 A. At the same time, if by improved methods of construction it can be shown that much lighter ships than those built to the rules for the 100 A class are as strong structurally as they, no reduction of freeboard would be made. The freeboards of spar and awning deck vessels require to be determined by considerations of strength, and the depth of loading thus being limited by the strength of the ship, it is obvious that extra protection afforded by sheer or by deck erections cannot be allowed to justify deeper loading. In these classes of vessels, therefore, no reductions for freeboard are allowed either for deck erections, sheer, or round of beam.

The freeboards of sailing vessels have been tabulated in a similar manner to the above, and corrections for deck erections, sheer, round of beam, &c., made in them in the same way. The Tables are framed for wood, composite, and iron ships, and call for no detailed description here.

A matter which has given rise to considerable discussion, is the regulation of freeboard according to the season of the year, and the nature of the trade in which a ship is employed. The committee have framed their Tables for winter voyages, and they allow a somewhat deeper loading for steamers in summer than in winter, but not for sailing vessels. An addition to the ordinary winter freeboard is required for the North Atlantic in winter. The allowances for summer voyages and for the North Atlantic voyages in winter will be seen in the Table on page 87. Double the reduction of winter freeboard that is allowed for summer voyages, is allowed for steamers trading during the fine season in the Indian Ocean, between the limits of Suez and Singapore. Summer voyages from European and Mediterranean ports are those made from April to September, inclusive; and in other parts of the world the reduced freeboard is allowed during the corresponding or recognised summer months.

The question of stability is one that has often been raised in connection with the regulation of freeboards. Stability is, however, so intimately associated with stowage that it is only possible to deal with it by defining how ships of various proportions and types are to be stowed. The Loadline Committee did not feel able to deal with an independent problem of such magnitude and such great complexity as this. Stability need not ordinarily enter into the determination of the loadline, except for the purpose of ensuring to ships of great proportionate depth the necessary stability at sea when employed in the carriage of grain, or any cargoes that are approximately homogeneous. If properly qualified persons are entrusted with the assignment of loadlines, they will readily distinguish between vessels in which stability is likely to be a question of importance and those in which it is not. In cases where vessels will obviously admit of being loaded so as to become unstable at sea, the owners should be looked to for particulars of the stability, and for furnishing proof that, so far as stability is concerned, the vessel may be safely laden with her intended cargoes to the loadline given in the Tables, or to such a reduced draught as may be considered proper. The responsibility of providing stability, or of showing that sufficient is provided, must be left with shipowners. Stability is regulated by stowage, and no mere provision of freeboard, height of platform, or strength of structure, can make a ship safe if her stability is not secured by proper stowage. The regulation of stowage has but little more to do with freeboard Tables than has the regulation of steam-power, bulkhead division, manning, and other essential elements of safety. Each of these points require to be separately and fully dealt with.

It will be seen, by the imperfect description thus given of the new loadline tables, that the committee did not succeed in discovering any simple rule that is applicable to all sizes, classes, and varieties of ships, and to all the circumstances under which they may be employed. Indeed, it must be clear, when the nature of the problem is properly considered, that no simple rule could possibly be devised that would discriminate fairly between the different types of ships, and that would take the special circumstances that affect all into account. While, on the one hand, as simple and as comprehensive a rule as can possibly be framed is, of course, highly desirable, it is necessary, on the other hand, to deal with each class of ship upon its merits, and to evaluate as correctly as possible, with reference to the exigences of the particular trade in which she is to be employed, each of the elements of seaworthiness that any ship may possess. It would have been easy to frame a rule much more complicated and much more difficult to use in practice than the Committee have recommended. The Committee have even gone the length, in several instances, of sacrificing exact scientific accuracy to simplicity, where no great amount of error has been involved, and where by so doing unanimity of opinion with regard to results has been obtained.

Those who look to the committee's report for purely theoretical modes of procedure, or for an absolute scientific standard of freeboard, will, doubtless, be disappointed. The committee had to be content with tabulating, as fully as the information before them would admit of, the experience of shipowners, and of others who have had to do with the loading of ships. This is the only basis upon which they could proceed. All who know the science that bears upon the subject, and who have any seagoing experience, must be aware that such science is at present powerless to deal fully with many of the principal points that are involved in the loadline question. It is to the behaviour of vessels at sea, and to the relation between freeboard and seaworthiness that experience has proved to exist, that we are obliged to look for the data upon which to construct any sound theory or any practical rules whatever. It is in this manner that the committee's Tables have been framed, and I do not suppose anyone who has had to do with them claims that they are absolutely perfect in every particular, or that they are incapable of future improvement in some of their details. Time and experience can alone show this; but the fair and friendly spirit in which they are being received by shipowners is very gratifying to all who have had to do with them, and encourages us to hope that such improvements as time may prove to be desirable may be made readily, and without undue friction between shipowners and the public authorities, if the practical administration of the Tables is carried out with knowledge, ability, impartiality, and discretion.

We are, however, obliged to regard the practical administration of these, or of any other freeboard Tables, as being almost of more importance than the Tables themselves. The most perfect Tables that can be framed must necessarily be incomplete in many particulars, and must leave a very great deal to the discre-

CARGO-CARRYING STEAM VESSELS NOT HAVING SPAR OR AWNING DECKS, NOR ANY DECK ERECTIONS.

Table of Reserve Buoyancy and Freeboard for First-class Sea-going Iron and Steel Steam Vessels. (In Salt Water.)

Coefficient of Fineness.	Per-centage Reserve Buoyancy.—(*Winter.*)									
	26·2	26·5	26·7	27·0	27·3	27·5	27·8	28·1	28·3	28·6
	Corresponding Height of Freeboard Amidships.—(*Winter.*) Measured from Top of Deck at Side.									
	Moulded Depth and Length.									
	ft. in. 19 6	ft. in. 20 0	ft. in. 20 6	ft. in. 21 0	ft. in. 21 6	ft. in. 22 0	ft. in. 22 6	ft. in. 23 0	ft. in. 23 6	ft. in. 24 0
	ft. 234	ft. 240	ft. 246	ft. 252	ft. 258	ft. 264	ft. 270	ft. 276	ft. 282	ft. 288
	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.
·68	3 5½	3 7½	3 9	3 11	4 0½	4 2½	4 4½	4 6½	4 8½	4 10½
·70	3 6½	3 8	3 10	3 11½	4 1½	4 3½	4 5½	4 7½	4 9½	4 11½
·72	3 7	3 8½	3 10½	4 0	4 2	4 4	4 6	4 8	4 10	5 0
·74	3 8	3 9½	3 11½	4 1	4 3	4 5	4 7	4 9	4 11	5 1
·76	3 8½	3 10	4 0	4 1½	4 3½	4 5½	4 7½	4 9½	4 11½	5 1½
·78	3 9½	3 11	4 1	4 2½	4 4½	4 6½	4 8½	4 10½	5 0½	5 2½
·80	3 10	3 11½	4 1½	4 3	4 5	4 7	4 9	4 11	5 1	5 3
·82	3 10½	4 0	4 2	4 3½	4 5½	4 7½	4 9½	4 11½	5 2	5 4
Correction in inches for a change of 10 feet in the length.	1·1	1·2	1·2	1·2	1·2	1·2	1·2	1·2	1·3	1·3
Deduction in inches for Summer Voyages.	2½	2½	2½	2½	2½	2½	3	3	3	3
Addition in inches for Winter, North Atlantic	3½	3½	3½	3½	4	4	4	4	4	4

tion of those who have to use them. The mere tables only apply to existing types of vessels; and of these existing types, they can only apply to vessels of high class which are in good condition. In the administration of the Tables, great discretion and knowledge are necessary, in order to use them with reasonable modifications, in view of changes in the types of ships, or of improvements in ships, that the continuous progress of naval architecture is certain before long to cause. The same discretion and knowledge are necessary in dealing with vessels which by reason of age, structural defects, more or less rapid deterioration, or of anything that may be observed in their condition, cannot safely or fairly be loaded as deeply as vessels which are in first-class condition. The great majority of the members of the committee are of opinion that, in order to give useful and satisfactory effect to the Tables, the scientific staff of the Board of Trade should be strengthened, and should be made capable of dealing with all questions of such a nature that may arise, in a manner likely to command the confidence of shipowners and of the public. They also think it essential that this work should be done under the superintendence of a representative body, which should consist not only of officials but also of shipowners, naval architects, seamen, and perhaps underwriters.

Parliament has laid upon the Board of Trade, by the Merchant Shipping Act of 1876, the duty of detaining any British ship which is, "by reason of the defective condition of the hull, equipment, or machinery, or by reason of overloading or improper loading, unfit to proceed to sea without serious danger to human life, having regard to the nature of the service for whch she is intended." This is a heavy responsibility, and it has been placed by Act of Parliament upon the shoulders of the Board of Trade. The authority or council recommended by the committee ought not, therefore, to be independent of the Minister responsible to Parliament, but should assist him in performing the duty which thus belongs to him as President of the Board of Trade. Such a body is essential if the committee's recommendations are to be carried into effect, while, if compulsory loadlines should ever be enforced—and public opinion appears to be setting in that direction—it will be still more necessary, because the question will then arise, not only of dealing with our own ships, but of enforcing loadlines upon all ships alike, both British and foreign.

In speaking of a compulsory loadline, we have to bear in mind that the present or any other official Tables may easily become compulsory for all practical purposes, under the present system, without any Act of Parliament or Board of Trade regulation stating that they are to be so. Any Tables that are used by Board of Trade officials for guidance in detaining vessels, or that are held by the Wreck Inquiry Courts to define a standard of safe loading, practically lead to the loadlines assigned by them becoming compulsory. The adoption cf an absolute standard by the Board of Trade, by the Wreck Inquiry Courts, and by the Law Courts of the country, must inevitably lead to the enforcement of pains and penalties against those who do not conform to it, just as would be the case if the Tables that constitute the standard were called compulsory. The members of the Loadline Committee have pointed out in their supplementary report that, if compulsory loadlines are enforced —and it does not matter whether they are called compulsory or not if they really become so—the course which should be taken in order to avoid "unduly interfering with trade," is to enforce such loadlines upon all ships, British and foreign, that load in British and Colonial ports, and strengthen the Marine Department of the Board of Trade in the direction of better qualifying it to perform these special duties.

DISCUSSION.

The CHAIRMAN expressed his regret that Professor Elgar had been unable, owing to the pressure of important engagements, to be present at the reading of his paper.

Mr. FRANCIS COBB said that while no one could doubt the great usefulness of this paper, he might, perhaps, be permitted to point out two passages which seemed to require correction. In one place it was stated:—"In fixing upon a standard of relative dimensions, it has been found that the influence of breadth upon freeboard may be safely ignored in all ordinary vessels; and it is sufficient to regard, in the Tables, only the relation of depth to length;" and further on occurred this passage:—"The coefficient of fineness taken for this purpose, which was proposed by Mr. Martell, is the following:—Divide 100 times the gross registered tonnage below the upper deck by the product of the length, breadth, and depth of hold, and the result will be the 'coefficient of fineness for freeboard purposes.'" In the one part consideration of the beam of the ship was disclaimed, and in the next place it was brought in to find the coefficiency of fineness. As reference had been made to well-decked ships, he might perhaps be permitted to say that it was the opinion of experts that these vessels were of the most disastrous form that had ever been invented.

Lord ALFRED CHURCHILL thought the basis which had been laid down by the Loadline Committee was one well deserving of commendation, as they had gone very fully into the whole of the question connected with the safety of vessels having a loadline, which, no doubt, must differ with various classes of ships. The principle of tonnage in its normal condition, as he took it, would be the displacement, but still it must not be forgotten that vessels of different forms would have perhaps the same amount of displacement. A short and broad vessel might carry a larger amount of cargo under ordinary conditions than one long and narrow, as the latter class of vessels could not be loaded up to the extreme ends with safety, so that the cargo had to be placed in the centre of the vessels. In steam ships, where large space was taken up by coals, a certain amount of stowage was lost, but on the other side speed was gained; and, therefore, the profits of a voyage might be made by speed rather than by the amount of cargo carried. The committee had laid down certain Tables which seemed well calculated for the purpose of carrying out the object in view. With reference to the last paragraph in the paper, he was disposed strongly to concur in the observations there made, namely, in the necessity for having a compulsory loadline; and he thought they should go back to the custom which prevailed in the days of William and Mary, of having the loadline marked by rails "on each side of the stem and stern and midships." It was necessary for large ships to have a compulsory loadline, because many shipowners, under certain conditions, were apt to alter the painted mark to suit the circumstances of the case. The loadline should be fixed by the builder at the time of building the vessel, and should be registered by the Board of Trade, so that being of a fixed quantity it could never be altered upon any occasion. He was not sure that it was even wise to alter it for a summer and winter cruise. He considered Fig. No. 1, which might be called a flush-decked vessel 100 A, would be naturally the best form of vessel under ordinary conditions, and after that, No. 3, or No. 5, which had a platform running round a house between the midships and poop. As to No. 7, he thought up to the lower line should be constructed in every way similar to No. 1, and it should be registered for tonnage in the same way; that the above portion should be an addition, but not capable of loading for purposes of heavy cargo. If this were done, you would have a thoroughly good, seaworthy ship, with a high upper deck, which should be used for the purpose of navigating the ship. No doubt such a ship would be better adapted for carrying passengers than cargo, but with a fixed loadline it would be a safe ship if properly navigated.

Mr. T. R. CRAMPTON thought that a fixed line was hardly the point to be guided by, as a vessel might be filled with wool, or iron, and brought down to a certain point, but in each case the centre of gravity would be different. His opinion was that it would be as well to get as near as possible to the centre of gravity.

Mr. LIGGINS said that would vary according to the weight of cargo.

Lord ALFRED CHURCHILL thought the maximum line should be marked during building, but he would not insist on a ship being loaded down to the mark.

Mr. LIGGINS wished to offer a few remarks from a shipowner's point of view, and he did so with great confidence, as he and his father had been for over fifty years engaged in the West India trade. During this period he had never lost a single ship, and upon one occasion only had a loss of life occurred. He quite agreed with Lord Alfred Churchill that there ought not to be any difference made in the loadline in summer and winter, for it very often happened that a ship which left dock in the summer, before arriving at her destination, had to face a severe hurricane; and if overloaded she might possibly founder and cause great loss of life. He considered the term "murder," which had been applied to shipowners by certain persons when discussing this question, was one of the most infamous aspersions that had ever been uttered. It was possible that sometimes a man was base enough to overload a ship with a view of obtaining the insurance money, but he was confident that this could not be said of the generality of shipowners. He hoped that the proposed regulations would never become law, because if they did, the result would be that many thousands of tons would be transferred to foreign registers. It was an impossible thing, by any scientific process, to fix a line for every ship, as ships varied so much in form. Reference had been made in the paper to the ignoring of the beam, but, to his mind, the beam was the greatest element of safety. It was the narrow ship, which did not rise sufficiently fast in a heavy sea, that was most likely to come to grief. He had very little respect for theoretical science after reading in the *Times* the account of the loss of the *Indus*, where it was stated "that the water steadily gained way, notwithstanding that the cargo was thrown overboard; finally the pressure burst in the bulkhead or partition and flooded the engine-room compartment when the vessel sank." That ship was built by a very celebrated firm, and no doubt every part was measured with mathematical precision, but, notwithstanding, it had foundered. He did not believe it was possible to fix upon a loadline which would be satisfactory to shipowners and captains. It was not so much overloading as the carrying of deck loads which caused the major part of the accidents that occurred. In reference to the accident to the *Palgrave*, which had been lately reported by the transport *Deccan*, he stated that this was about as dangerous a kind of ship as it was possible to construct, as it was too large and unmanageable for the crew carried.

Mr. HENDERSON, speaking as a shipowner of forty years' standing, and as having owned vessels engaged in trade with all parts of the world, said he was exceedingly anxious that a loadline should be adopted, and he was sure this was the wish of the majority of shipowners. Mr. Plimsoll might have been indiscreet in some of his remarks, but the legislation which had been passed consequent upon his agitation, had been the means of preventing great loss of life upon ships that would have gone to sea, had they not been prevented from leaving port in consequence of what he had done. If a loadline had been adopted twenty years ago, there would not have been the loss of life that there had been. He highly approved of what Lloyd's committee had done in endeavouring to have a loadline put upon ships when shipowners were willing to do it, and was glad to find the Loadline Committee had adopted the loadline which Lloyd's recommended.

Mr. MARTELL, in support of the remarks of the last speaker, said that shipowners were continually applying to Lloyd's to affix freeboards to their ships. Whatever might at one time have been the opinion of shipowners upon this point, he had no hesitation in saying that they now believed it would be far better in their own interests, as well as in the interest of the general community, to have a loadline fixed by some responsible body. With regard to narrow ships, he thought owners were going to too great an extent in increasing the beam of vessels; that element had, he might say in reply to one of the speakers, been taken into consideration in framing the Table for freeboards. With regard to Fig. 7, he fully coincided in the remarks which had been made by Lord Alfred Churchill, and there was no doubt that Fig. 1 was an excellent type of ship; but when it was an ordinary one- or two-decked ship, with full scantlings up to the upper part, and had no protection by a forecastle or poop at the after-end, or bridge-house in the middle, to prevent the waves coming on board, it was not so safe as ships that had proper erections on them, unless there was a continuous superstructure, as in Fig. 7, where there was a high freeboard, by having seven or eight feet out of the water, irrespective of the height of the freeboard from the main deck. Mr. Cobb had denounced well-decked ships as most dangerous, but experience had shown they were among the safest types of ships. In proof of this, he might mention that lately an insurance society had been established on the north-east coast which only took in this class of ship, and the premiums were the smallest ever paid. It was also proved, by statistics, that fewer ships of this type were lost than any other kind. No doubt, formerly, well-decked ships were differently built to what they were now, but attention was now paid to protecting all the vulnerable parts, and hence the safety of this class of vessels. He was glad to hear from Mr. Henderson that shipowners generally approved of the labours of the Loadline Committee, for he had no doubt that they would be benefited by having a line affixed, rather than by allowing vessels to go to sea at the discretion of those who, in many cases, had no practical experience of the subject, as had been suggested by Mr. Liggins. The Tables which had been drawn up were founded on practice, and science was only brought in to utilise the practice. Had it not been for the scientific knowledge, ability, and tact of the Chairman, he was certain the committee would never have arrived at the unanimous conclusion it had, and great thanks were due to Sir Edward Reed for what he had done.

Mr. COBB wished to explain that when he said the beam was not taken into consideration in the calculation of the loadline, he did not say so upon his own word, but upon what was stated in the paper, and he merely pointed out that it was inconsistent with a further passage. The same observation also applied to well-decked ships.

The CHAIRMAN said the Loadline Committee, in the inquiry which they undertook, had a very difficult task to perform. The origin of that committee was this: the Legislature having placed the obligation of stopping the overloading of ships on the Board of Trade, that Department tried to do so, but failed to succeed, their interference being resisted by shipowners. Thereupon Mr. Chamberlain conceived the idea of forming a committee of gentlemen for the purpose of thoroughly investigating the subject, and seeing what answers could be given to the questions which had been referred to in the paper. Mr. Chamberlain deserved great credit for what he had done, as from the constitution of the committee he exhibited a great desire to bring into it all kinds of knowledge and experience; he also accepted modifications in the constitution, for the purpose of giving a further representation to different classes of shipowners, and from the time the committee was organised he never said a word, or did a thing, by way of influencing their action. The best proof that the committee had done its work with a fair measure of success was to be found in the fact that no one had that evening complained of the results at which they arrived, which would not have been the case had mistakes been committed, as shipowners never hesitated to defend themselves. He was one of those who believed that shipping had been over-legislated and unwisely legislated for, and that a great many reflections had been cast on shipowners which ought to have been more strictly limited to an extremely narrow section of their number. With regard to the remarks of Mr. Cobb, he must confess that the correction which had been made was not wholly unjustified, though Professor Elgar in the following paragraph fully explained what he meant. Breadth was considered in the construction of the coefficients of fineness which had been adopted by the committee, and they were not adopted without very serious investigation and most elaborate calculations. It was due to Mr. Duncan and Mr. Denny to say that they carried out very laborious investigations for the express purpose of ascertaining whether the coefficient of Mr. Martell did closely approximate to what would be the result of actual detailed calculation. At an early stage of the inquiry he (the Chairman) laid some views before the committee touching the coefficients, with the object of seeing how far theoretical objections which might be taken had any practical value, and he was glad to say that they were found to have next to none. The Tables, in so far as that branch of the question was concerned, were the consequence of most laborious investigation. The committee had appeared before the world as a unanimous body, not exhibiting a single difference of view, but that was due to the thoroughness with which every branch of the subject was investigated and debated, and to the good sense of the members. He did not quite understand the theory that science was objectionable, particularly when that science was illustrated by particulars which went to show that there was a lack of science in the cases brought forward. If a bulkhead burst in consequence of being too weak, that proved there was a deficiency and not an excess of scientific knowledge. Notwithstanding the public denunciations of well-decked ships, he agreed with Mr. Martell that in the improved and modern form, they were the safest ships that went to sea. Before concluding, there were one or two points in the paper to which he might perhaps be permitted to refer. Professor Elgar, as was very natural in writing the paper, had gone rather behind the scenes, and made statements, as it were in the name of and on behalf of the committee, which were not based upon the Report or the Tables of the Committee. For example, in so far as the Tables dealt with the principle of reserved buoyancy, the committee, for the sake of being unanimous, agreed to put nothing in the report that would tend to indicate that reserved buoyancy was the basis of their proceeding. The fact was it was an eminently practical committee, and what was done was this: after thrashing out theoretically and scientifically, and certainly practically, a great many branches of the subjects, they agreed to drop the reasons, like the wise judge who gave his decision without stating the grounds upon which he based it. He might, perhaps, qualify a little the remark about stability, where Professor Elgar spoke as if the committee had rather avoided the question, or found it too difficult to deal with. This was not quite so. It was not the magnitude of the problem which deterred the committee from dealing with it, but the true reason was that stated further on by Professor Elgar, namely, that stability was regulated by stowage, and no mere provision of freeboard, height of platform, or strength of structure could make a ship safe if her stability was not secured by proper stowage. If they had taken another view, great injury might have been inflicted on shipowners. It was well known you might have a ship very unstable with a homogeneous cargo, which could be made stable, or even a great deal too stable—by putting in an iron cargo, for instance, or by disregarding the question of the centre of gravity, and other considerations. Therefore it was that the committee felt it would be a very great mistake to attempt to regulate the amount of loading, or in other words, the position of the loadline of the ship, by a consideration which might or might not exist, according to the nature of the cargo carried. Of course it followed on the other hand from this that a ship, though loaded to a suitable loadline, if she was badly stowed, might go to sea in a very unsafe condition. There was no disguising that fact, and Professor Elgar had shown how necessary it was to supplement the labours of the committee by further knowledge and investigation touching other elements of the safety of ships at sea. It was right, he should say, notwithstanding some little internal contests over small details of principle, that the representatives of the Board of Trade upon the committee yielded to the views of the majority, where they conscientiously could, with considerable grace. Nothing he could say would be too strong in the way of approval of the labour of Lloyd's Register Office, and particularly of the individual labour of Mr. Martell. That gentleman had responded to every desire of the committee for further information which lay within his reach, and in this course he was supported by his committee and all the officers of Lloyd's. He was sure that every one would agree that the committee had done valuable work in shewing that means had been at last reached for bringing about a concurrence of opinion between shipowners and those who were charged with the responsibility of regulating the loading of merchant ships. He believed shipowners also came out exceedingly well in the inquiry, both in the evidence they laid before the committee and in the manner in which they applied their knowledge and experience to the investigation, and he should feel it his duty, when he saw Mr. Chamberlain, to point out to him that nothing could have been more fair-minded, more open or thorough, than the manner in which they co-operated with the other members of the committee in bringing about the result which had been attained. In conclusion, he begged to propose a hearty vote of thanks to Professor Elgar for his valuable and important paper.

The resolution was passed unanimously, and the meeting adjourned.

Miscellaneous.

INTERNATIONAL INVENTIONS EXHIBITION.

JURY AWARDS.

The final list of awards made by the Juries, and confirmed by the Jury Commission, has now been issued, and can be obtained from Messrs. Clowes, the publishers to the Exhibition. The list contains the awards in both Divisions of the Exhibition—Inventions and Music, also the awards which were made to exhibitors in "Old London." Since the issue of the first edition of the list, the Jury Commission have been engaged in considering applications from exhibitors who were dissatisfied with their award. In cases where any error seemed to have been committed, or where the exhibit had been overlooked, the Jury Commission have endeavoured to repair omissions or correct mistakes; but the comparison of this list with that which appeared in the *London Gazette* of the 11th of August last, will show that the alterations have not been very numerous. The Jury Commission, now that its work is completed, has been dissolved. The design for the diploma, which has been drawn by Mr. Thomas Riley, has been approved by the Executive Council of the Exhibition, and is now in the printers' hands. There seems every reason to expect that a diploma will be forwarded to each exhibitor who has received a medal within two months from the present time. The medals will be distributed as soon as they are ready, and this, it is believed, will be very shortly.

PRODUCTION OF ALFA IN ALGERIA.

Consul General Playfair, in his last report issued at the commencement of the year, on the commerce and agriculture of Algeria, says that alfa is of great and increasing importance, both to Algeria and England, where nearly the whole of the exports are consigned, and he gives the following account of the plant taken from the report of a Commission recently sent to the high plateaux by the Governor-General, to study the subject in the great upland plains where alone it is found. Alfa or halfa is a plant which is found in calcareous soil or silicious clay, but not in compact clay or pure sand, unless, at a short depth below them, silicious clay is found, or soil unimpregnated with sea salt. In the high plateaux of the south of Oran it is found in calcareous soil of the formation *cretacée supérieure* (compact calcareous rock, in horizontal bands, the decomposition of which produces stones and finely powdered earth coloured dark red by the oxide of iron), and in sand mixed with clay of quaternary alluvium. The thin circular and shallow roots of the plant require air and a little moisture, thus the alfa is never found in the white sand near the *Chotts*, nor in the depressions of compact soil scattered about the high plateaux. The surface of the high plateaux in Oran may be compared to a carpet, the ground of which is alfa, picked out with innumerable ramifications of *sennara* and *artemisia*. The tuft of alfa presents at its base the appearance of a central axis around which at a short distance proceed horizontal ramifications. These spring up vertically and produce bunches of flowers, sheathed in narrow falling leaves. After the first year's growth, each ramification sends out from its base a shoot, which descends into the ground, producing a small root; other ramifications are then produced at the base of previous ones, and become rooted in their turn. The tuft thus increases from the centre to the circumference, each addition being united to the central mass, but forming gradually its own roots, so as to be able to live when the central part dies and disappears. It is only in the third year from the sprouting of the ramification that the flower appears to be developed. If the plant is allowed to grow unchecked, its flowers and leaves vegetate during the spring, they ripen in summer, and they commence to decompose from the points downwards, under the action of the autumnal rains, fading progressively during the winter. In proportion as the sap of spring developes new leaves, those of the previous year fall over inert and partly dried up, without ceasing to adhere to the stem on which they continue to decompose during the following years. After several years the dead leaves form a thick central mass, impenetrable to the shoots at their base, and around this mass the new leaves pierce through, and the small roots continue to develop outside the circle. Alfa grows abundantly in Algeria, and a large population, both of Spaniards and Arabs, is engaged in collecting it. The workman generally twists round his hand, or round a small stick, the upper part of the leaves, which he tears out by a sudden jerk, and puts under his left arm, and this he continues to do until he has made a small sheaf which he ties up. A number of these small sheaves are made into a larger one, and these are placed upright to dry. To preserve this plant as much as possible, an ordinance of the Governor-General was published on the 13th March, 1884, prohibiting the collection of it during a close period of about four months every year, varying according to the climatic conditions of the district where it occurs. A large quantity of the best alfa is exported to Spain, where it is mixed with the esparto grass of the country; the ordinary quality is almost all sent to England for the manufacture of paper. Of late the exportation has greatly diminished, owing partly to the competition in Spain, Morocco, and Tunis, but partly to its excessive price and the introduction of wood pulp in the paper trade. The extent over which the alfa is found in Algeria is about 4,441,000 acres, and it is estimated that upwards of 16,000,000 cwts. were collected during the year 1883.

Notes on Books.

LIGHTNING CONDUCTORS. By Richard Anderson. Third Edition. E. and F. Spon. 1885.

The object of this work is to give full information as to the precautions to be taken to protect buildings from lightning, the best means of setting up and arranging lightning conductors, &c. In addition to this, a very full history of the invention of the lightning rod and of the early experiments of Franklin and others is given. The present is the third edition of the book, and contains considerable additions to the matter which was found in previous issues. The whole book has been read and revised by Dr. R. J. Mann.

JOHN WYATT. Compiled from original manuscripts. Hamilton Adams and Co. 1885.

There are probably not many people who are aware that the spinning machine of Hargreaves was anticipated many years before by the invention which was patented by Louis Paul in 1738, and fewer still that the invention for which Paul took out a patent was really the work of John Wyatt. In this little book a full account of Wyatt is given, and it shows that he not only was the first to invent a method of spinning by machinery, but that he also invented and carried to a certain degree of perfection a file-cutting machine, and also a weigh-bridge capable of weighing loaded wagons. A machine of his construction was set up for the public use in Liverpool in 1744. Similar machines were also erected a few years later in Shrewsbury, Chester, and elsewhere.

THE DOMINION ANNUAL REGISTER AND REVIEW FOR THE EIGHTEENTH YEAR OF THE CANADIAN UNION, 1884. Toronto. 1885.

This volume, which is the eighth of a series of Annuals, contains a Political and Parliamentary History for 1884, and a chapter on the progress of education in the Dominion, a review of literature, science, and art, a full obituary for the year, statistics, and a journal of remarkable occurrences. The appendix contains, among other things, a table of ages, and other data respecting living Canadian public men, and a list of *voyageurs* with the Nile Expedition.

General Notes.

EDINBURGH INTERNATIONAL EXHIBITION, 1866.—The full programme of this Exhibition has now been issued, containing the classification, lists of committees and sub-committees, regulations, &c. The rules are based on those which have been found to work successfully at the South Kensington Exhibitions. The Exhibition is to be an international one, and contributions from foreign countries are invited. "Old London" is to have its imitator in "Old Edinburgh," as it is proposed to reproduce some of the historical buildings of Edinburgh in the manner which has been so successfully adopted at South Kensington for old London houses. There are to be special departments for fine arts, women's work, and the work of artisans.

NAVIGATION OF THE SEINE.—Although Paris cannot strictly be termed a seaport, the quantity of goods brought by water is greater than the export and import trade of any port in France, and averages upwards of $5\frac{1}{2}$ millions of tons annually; whilst at Marseilles, the total exports and imports taken over a period of three years does not average more than $4\frac{1}{2}$ millions of tons per annum. It is true that, as a commercial port, Paris cannot rank high, as the exports are insignificant as compared with the imports. About 80 per cent. of the total tonnage brought up the Seine consists of timber and other materials for building purposes, whilst agricultural produce and provisions figure for about 380,000 tons. As an industrial centre, Paris does not avail itself of river transport for the export of its manufactures—450,000 tons at the utmost—and it would be necessary to reduce the cost of freights. On 100 vessels and boats which bring goods to Paris, 82 return empty.

MEETINGS OF THE SOCIETY.

ORDINARY MEETINGS.

Wednesday evenings, at 8 o'clock:—

DECEMBER 16.—"Burmah, Present and Future." By HOLT S. HALLETT.

At the meetings after Christmas the following papers (among others) will be read:—

"The Treatment of Sewage." By Dr. C. MEYMOTT TIDY.

"Calculating Machines." By C. V. BOYS.

"The History and Manufacture of Playing Cards." By GEORGE CLULOW.

"Domestic Electric Lighting." By W. H. PREECE, F.R.S.

"The Scientific Development of the Coal Tar Industry." By Prof. R. MELDOLA, F.C.S.

"The Experiments with Lighthouse Illuminants at the South Foreland." By E. PRICE EDWARDS.

"Machinery in Mines." By HENRY DAVEY.

FOREIGN AND COLONIAL SECTION.

The Meetings of this Section will take place on the following Tuesday evenings, at Eight o'clock:—

January 26; February 16; March 2, 23, April 13; May 18.

APPLIED CHEMISTRY AND PHYSICS SECTION.

The Meetings of this Section will take place on the following Thursday evenings, at Eight o'clock:—

January 28; February 11, 25; March 11; April 8; May 13.

INDIAN SECTION.

The Meetings of this Section will take place on the following Friday evenings, at Eight o'clock:—

January 22; February 19; March 19; April 2; May 7, 21

CANTOR LECTURES.

The First Course will be on "The Microscope." By JOHN MAYALL, Jun.

December 14, 21.

The Second Course will be on "Friction" By Prof. H. S. HELE SHAW.

January 18, 25; February 1, 8.

The Third Course will be on "Science Teaching." By Prof. F. GUTHRIE, F.R.S.

February 15, 22. March 1.

The Fourth Course will be on "Petroleum and its Products." By BOVERTON REDWOOD, F.C.S.

March 8, 15, 22, 29.

The Fifth Course will be on "The Arts of Tapestry Making and Embroidery." By ALAN S. COLE.

April 5, 12, 19.

The Sixth and Concluding Course will be on "Animal Mechanics." By B. W. RICHARDSON, M.A., M.D., F.R.S.

May 3, 10, 17, 24, 31.

JUVENILE LECTURES.

The Two Juvenile Lectures on "Waves" will be given by PROF. SILVANUS P. THOMPSON, D.Sc., on Wednesday evenings, December 30th, 1885, and January 6th, 1886. Special tickets will be issued for these lectures.

ADMISSION TO MEETINGS.

Members have the right of attending all the Society's meetings and lectures. Every member can admit *two* friends to the Ordinary and Sectional Meetings, and *one* friend to the Cantor Lectures. Books of tickets for the purpose have been issued to the members, but admission can also be obtained on the personal introduction of a member.

MEETINGS FOR THE ENSUING WEEK.

MONDAY, DEC 14...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. (Cantor Lectures.) Mr. John Mayall, jun., "The Microscope." (Lecture IV.)

Geographical, University of London, Burlington-gardens, W., 8½ p.m. Colonel C. Stewart, "The Herat Valley and the Persian Border, from the Hari-rud to Seistan."

British Architects, 9, Conduit-street, W., 8 p.m.

Medical, 11, Chandos-street, W., 8½ p.m.

London Institution, Finsbury-circus, E.C., 5 p.m. Captain V. L. Cameron, "The Heart of Africa."

TUESDAY, DEC. 15...Civil Engineers, 25, Great George-street, S.W, 8 p.m. Discussion on Mr. John Imray's paper "High-Speed Motors," and on Mr. Gisbert Kapp's paper. "Continuous-Current Dynamo-Electric Machines, and their Engines."

Statistical, School of Mines, Jermyn-street, S.W. 7¾ p.m. Mr. Thomas Scrutton, "Preventible Loss of Life at Sea."

Pathological, 53, Berners-street, Oxford-street, W., 8½ p.m.

WEDNESDAY, DEC. 16...SOCIETY OF ARTS, John-street, Adelphi, W C., 8 p.m. Mr. Holt S. Hallett, "Burmah, Present and Future."

Meteorological, 25, Great George-street, S.W., 7 p.m. 1. Dr. A. Woeikof, "The Influence of Forests upon Climate." 2. Rev. T. A. Preston, "Report on the Phenological Observations for 1885." 3. Prof. A. Ricco, Etudes sur les crépuscules rosées." 4. Col. M. F. Ward, "The Storm of October 15th, 1885, at Partenkirchen, Bavaria."

Geological, Burlington-house, W., 8 p.m. 1. Mr. G. Wareing Ormerod, "Old Sea-beaches at Teignmouth, Devon." 2. Prof John W. Judd, "The Gabbros, Dolerites and Basalts of Tertiary Age in Scotland and Ireland."

Institute of Patent Agents, 55, Chancery-lane, W.C., 7½ p.m. 1. Resumed discussion on Mr. Imray's paper, "The Establishment of a Roll of Patent Agents." 2. And Mr. Lloyd Wise's paper, "Patent Agents, their Profession considered as a Necessity, with Suggestions for Reform."

Royal Society of Literature, 4, St. Martin's-place, W.C., 8 p.m.

Civil and Mechanical Engineers, 7, Westminster-chambers, S.W., 7 p.m. Mr. Eedes Eachus, "Ventilation of Sewers."

THURSDAY, DEC. 17...Royal, Burlington-house, W., 4½ p.m.

Antiquaries, Burlington-house, W., 8½ p m.

Linnean, Burlington-house, W., 8 p.m. 1. Dr. J. S. Brady, "Ceylon Entomostraca." 2. Mr. H. N. Ridley, "Madagascar Orchids." 3. Rev. A. Eaton, "Recent Ephemeridæ." (Part IV.) 4. Mr. J. Baly, "Colombian Species of Diabrotica"

Chemical, Burlington-house, W. 8 p.m. 1. Mr. H. B. Dixon, "The Action of Steam on Carbonic Oxide." 2. Miss E. Aston and Mr. S. U. Pickering, "Multiple Sulphates."

London Institution, Finsbury-circus, E.C., 7 p.m. Captain Abney, "Light and the Atmosphere."

Historical, 11, Chandos-street, W. 8 p.m.

National Indian Association, Westminster-palace Hotel, S.W., 4 p.m. Dr. D. H. Cullimore, "Personal Recollections of Burma, its Court, People, and Climate."

FRIDAY, DEC. 18...Civil Engineers, 25, Great George-street, S.W., 7½ p.m. (Students' Meeting) Mr. F. Geere Howurd, "The Propulsion of Tramcars and Launches by Secondary Batteries."

Philogical, University College, W.C., 8 p.m.

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FRIDAY, DECEMBER 18, 1885.

All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

NOTICES.

JUVENILE LECTURES.

The usual short course of lectures, adapted for a juvenile audience, will be given on Wednesday evenings, December 30th, 1885, and January 6th, 1886, by Professor SYLVANUS P. THOMPSON, on "Waves." The lectures will commence at seven o'clock. Nearly all the tickets having now been disposed of, the issue will be stopped on Monday next, December 21st. As all the available accommodation will be required for those members who have applied for tickets, it will be understood that no member can be admitted without a ticket.

CANTOR LECTURES.

On Monday evening, 14th inst., Mr. J. MAYALL, jun., delivered the fourth lecture of the course on "The Microscope." The microscopes exhibited at the lecture were lent by Mr. Frank Crisp, Secretary of the Royal Microscopical Society.

EXHIBITION OF MICROSCOPES.

The Exhibition of Microscopes will remain open during the period of the delivery of Mr. Mayall's Cantor Lectures, daily from 10 to 4 (on Saturdays from 10 till 2). Members can admit their friends to the Exhibition by the use of the tickets supplied for the evening meetings and lectures.

UNION OF INSTITUTIONS.

The following Institution has been received into Union since the last announcement:—

The Teachers' Guild of Great Britain and Ireland. 17, Buckingham-street, Adelphi, London, W.C.

Proceedings of the Society.

FIFTH ORDINARY MEETING.

Wednesday, December 16th, 1885; J. M. MACLEAN, M.P., Member of Council, in the chair.

The following candidates were proposed for election as members of the Society:—

Acland, Alfred Dyke, 38, Pont-street, S.W.
Adams, Captain, 7, Trafalgar-square, Fulham-road, S.W.
Bone, William John, 61, Linskill-terrace, North Shields.
Butcher, James, High-road, Gunnersbury, W., and National Liberal Club, S.W.
Creese, Edward James Edgell, Roman-villas, Cirencester.
Innes, Charles A., M.D., 21, Montague-street, Russell-square, W.C.
Manuel, George Watson, Fernbank, Catford-hill, S.E.
Morgan, Edward Vaughan, Battersea Works, S.W.
Pearce, William, Leadenhall-buildings, Leadenhall-street, E.C.
Pirrie, W. J., Queen's Island, Belfast.
Varley, Fleetwood E., 2, Vernon-chambers, Southampton-row, W.C.
Wheatley, William Coe, The Elms, Trinity-road, Upper Tooting, S.W.
Whitaker, William, 33, East Park-terrace, Southampton.

The following candidates were balloted for and duly elected members of the Society:—

Bedford, George, Art School, Torquay.
Bostock, Edwin, Stone, Staffordshire.
Brenchley, Algernon, M.D., 124, Denmark-hill, Camberwell, S.E.
Chichgur, Darasha Ratanjee, Girgaum-road, Bombay.
Glanville, Francis Ferratus, Grove-house, 140, Fulham-road, S.W.
Hawkins, Major, 51, Harrington-road, Hampstead-road, N.W.
Turpin, Edmund Hart, 6, Argyle-square, W.C.
Westfield, C. Marcus, Sheen-lodge, Warwick-road, Upper Clapton, E.

The paper read was—

BURMAH, PRESENT AND FUTURE.

By Holt S. Hallett, M.Inst.C.E., F.R.G.S.

I come before you this evening to address you on the subject of Burmah. Upper Burmah, and the Shan States lying to the east of it, which were until lately under its control, should be of the greatest interest to us as a trading nation, for they are interposed between the two most populous empires in the world, India and China. In these days, with foreign competition getting keener every day, and hostile tariffs not only shutting the European markets against us, but in a lesser degree America and English colonies also, with the race for fresh colonies and new markets among the European powers, it is of importance that we should avail ourselves of our present opportunity for an inland connection and commercial alliance with Indo-China and China, and thus acquire new markets of transcendent promise.

Burmah and the Burmese Shan States are highly favoured by their geographical position. They lie in the course of the monsoons, and are gifted for the most part with a plentiful rainfall. Even in places where the rainfall, owing to the encompassing hills, is scarce, the plains receive a bountiful supply of water from the hill streams, which admit of cultivation by means of irrigation. The climate is humid, and the forests and other vegetation are unsurpassed by that of any other region.

Burmah is bounded on the north by the snow-clad hills of Southern Thibet; on the east by China, the Shan States tributary to China, to Burmah, and to Siam, and Siam; on the west by Assam, Manipur, Chittagong, and the Indian Ocean; and on the south by the Indian Ocean and Siam. It may be said to exist in four natural divisions, one of which, comprising the province of Aracan, borders the Bay of Bengal; the second, and by far the most fruitful and important, the basins of the Irrawaddi, Sittang and Beeling rivers; the third, the portion of the basin of the Salwen that lies to the south of Karennee and as far west as the Thoungyden river; the fourth, the portion of our province of Tenasserim lying along the Indian Ocean.

Aracan is bordered on the north by Chittagong, on the south by the Gulf of Martaban, and on the east by the crest of the Aracan "yoma" hills. It is for the greater part a mass of mountains, enclosing small plains at different elevations, the spurs from the main range generally extending to the seaboard. The numerous tidal creeks and rugged hills render land communication between neighbouring districts nearly impracticable.

There are several passes, notably those of Aeng and Tonghoop, by which pack carriage is maintained with the valley of the Irrawaddi. The chief harbours are those of Akyab and Kyouk-Phyoo, the hills are the home of a great variety of hill tribes, and the plains are inhabited by the Aracanese or Yakine, who are a branch of the Burmese race. According to their chronicles, their first dynasty commenced in Aracan in B.C. 825.

The second portion of Burmah may be divided into three regions, lying within the basin of the Irrawaddi, which respectively formed the ancient kingdoms of the Peguan or Mon, the Burmese, and the Shan races, but were, with Aracan, Assam, Cachar, and Manipur, comprised in the Burmese Empire at the time of our first Burmese war, in 1826.

It may be well to take a cursory glance at the history of the country. The Peguans held the country between the Gulf of Martaban and Akouk-toung, the revenue station on the hills bordering the Irrawaddi at the head of the delta. Their first known capital was built at Thatone, near the eastern shore of the Gulf of Martaban, about B.C. 550. The Peguans drove the Pyu tribe of Burmese out of Prome, A.D. 84; and they seem to have remained dominant until A.D. 1050, when the Burmese for about 230 years kept Pegu subject to them. From A.D. 1287 to A.D. 1540, Pegu was ruled by Shan kings. In 1540, the Burmese King of Tonngoo, a city which is now our northern frontier post on the Sittang river, conquered Pegu, and during his reign became Emperor likewise of Ava, Prome, Toungoo, and Martaban. The Burmese ruled over these countries, with subordinate kings at their capitals, until 1740, when the Peguans rebelled, and freeing themselves, marched into Upper Burmah, and captured Ava, the capital. Thirteen years afterwards, in 1753, the Burmese, under their great Emperor Aluangphra, not only recovered their liberty, but likewise reconquered Pegu; and the two countries remained under the Burmese rule until we annexed Pegu in 1852. The Siamese province of Tenasserim, as well as Aracan, were annexed by Aluangphra a few years afterwards. The Shan States became tributary to the Emperor of Pegu in 1556.

The Burmese, like the Kakhyens and many others of the hill tribes, are akin to the Thibetans, and belong to the Turanian family. They occupied the country from Akouk-toung as far north as latitude 23½°. According to the Burmese, their first capital, Tagaung, was erected by Abhi Rajah, a Sakya prince of Northern Iadia, who entered Burmah with a large army about B.C. 850, and conquering the many Burmese tribes then in the country, founded his dynasty. Whether the Burmese chronicles are reliable in their dates or not, it is evident, from the letters found stamped upon bricks in the city of Tagaung, that that city was in existence more than 1,600 years ago.

The hills on both sides of the Burmese country have been occupied, as far as tradition extends, by hill tribes, those on the west being offshoots of Kolarian and Thibetan tribes, and those on the east by a conglomeration of Lawas, Karens, Shans, Kakhyens, Moosurs, and many other races, tributary to the Burmese when the latter could assert their power, but never entirely subjugated by them.

The northern portion of the Irrawaddi valley lying between lat. 23½° and the sources of the river, has been occupied by the Shans from about the commencement of our era, and divided into several Shan principalities, those to the east of Bhamo being now under Chinese domination, but still under their native princes. The inhabitants of the Shan States of Thebaw and Theinni on the Myit-Ngé river, as well as those of Thoung-Thwot on the Khyendwen river, and of Kampti, lying near the sources of the Irrawaddi, have been for some time in rebellion, owing to the oppression and cruelties of the Burmese. The Shans of Thebaw and Theinni, together with those of Monay and other States, driven to desperation and revenge, have been lately ravaging the country up to the very gates of the Burmese capital. Had we not interfered, the whole of the country would soon have been in a state of turbulence and disorganisation, which would not only have stopped trade, but have led to serious complications on our frontier.

There are many large plains in the two upper divisions of the Irrawaddi, notably that in the Hookong valley, at the sources of the Kwendwen, situated 11,000 feet above the sea, and fifty miles long, by from fifteen to forty-five miles broad; the plains in Kampti, which Wilcox found to be at an altitude of 1,855 feet and of considerable breadth; the Mandalay plain, sixty miles long, with an average breadth of ten miles; the Yemethen and Hlinedet plains, lying between Mandalay and our frontier, and many others bordering the Irrawaddi, and lying in lacustrine compartments along the branches of that river.

The Sittang valley, which lies to the east of that of the Irrawaddi, is connected with it by the Yemethen and Hlinedet plains. The Sittang appears to have been at one time an effluent of the Irrawaddi, but from subsequent silting of the water-way in the Yemethen plain, the passage has become blocked, and the Panboung, which at one time was the upper course of the Sittang, and now has its mouth within a few miles of Mandalay, is separated from the former river, and flows into, instead of from, the Irrawaddi.

The Sittang has now its western source in the Yemethen plain, and its eastern in the Pounglounng hills bordering the Shan plateau. It is bounded on the west by the Pegu-Yoma mountains, which rise to the east of the Yemethen plain, and terminated southwards at the hillock on which is built the great Shway-Dagon Pagoda at Rangoon. The hills are densely wooded, and owing to the ravines, communication between the valleys of the Sittang and Irrawaddi is only carried on by pack animals and coolies. The loftiest peaks of this range are about 1,200 ft. in height, and the average elevation is 800 ft. Between the main range severing the Salwen from the Sittang and the valley of the Sittang, are long spurs, or rather branch ranges of hills, averaging from 2,000 ft. to 6,000 ft. in height, dividing which are torrents and hill streams running generally in cañons, which render the country most difficult and nearly impassable even along the caravan routes that exist. This hilly country is a perfect maze of mountains, and has the appearance in many parts of a desiccated plateau.

These hills continue southwards to the latitude of Beeling, and embrace the valley of the river of that name. They are separated from the Martaban range of hills by the Kyouksareet Choung, a stream that is navigable during high floods, and connects the waters of the Beeling river with those of the Salwen. This passage at one time was most likely one of the exits, if not the sole exit of the Salwen river seawards, for the hills at Martaban and Maulmain, between which the river now runs, show signs of former connection, a broad band of rocks still appearing at low water across the greater part of the channel. It has been proposed to facilitate the water communication between the Sittang and Salwen rivers by cutting a canal through the Khykehto plain and along the Kyouksareet Choung, and thus to enable boats to pass by inland waterways from Rangoon to Maulmain, throughout the year.

At the point where the Sittang river crosses our frontier, the hills draw in on both sides near the river, and cultivation merely exists on the plains of the branch streams and on the hillsides. A few miles lower down, however, the Pegu-Yoma mountains recede, and the plain gradually increases in width to four miles at Toungoo, a frontier town which lies 37 miles to the south of our frontier, and further down stream to about 25 miles in width. The Sittang river at Toungoo rises from 18 ft. to 24 ft. in the rains, and is navigable for small steamers. The total length of the river, in a straight line, is about 350 miles, but the stream is so tortuous that the development of the 175 miles lying within our territory is little short of 300 miles. Throughout its course in the dry season it is shallow and full of shoals, but steamers of light draught can ascend to Htantabeng, whence there is a good bridged road to Toungoo. A canal has been made to facilitate the water communication between Rangoon and the Sittang river. The river cannot be approached with safety from the sea, as at its mouth a "bore" occurs during the spring tides about 20 ft. in height.

At low water, as far as the eye can see, the country near the mouth is a succession of low mud flats, the sea receding for 15 or 20 miles from the coast, and the course of the Sittang, Beeling, Thatone, and other streams wending in a serpentine course through the mud and sandbanks. The first appearance of the approach of the tide is marked by the flight of pelicans, storks, and other birds, which are driven landward by the inrush. The "bore" or tide wave is seen advancing, rolling up through the channel with a low rumbling sound, which gradually becomes more and more audible, forewarning all the fishermen and boatmen of its advance. Frequent disasters have occurred to people on the river—including some years ago a detachment of our troops—who have neglected to escape into the bye-creeks, out of the way of the bore, which comes rolling up the river, and with its after-rush of foaming water inundates the low-lying coasts. Round the outside of the serpentine bends of the river, I have seen the trees for some distance inland levelled and lying, dashed down like a pack of cards, by the force of an unusually high wave.

Owing to the sparse population in the Sittang valley, and the consequent amount of waste land, many of the streams have been "bunded" by the fishermen, without complaints being made to the authorities. This custom has ruined many of the streams, through the people neglecting to remove the "bunds" before the commencement of the rains. The streams, therefore, silt up above the dam, and the upper waters, finding weak places in the silt-formed banks, breach them, and flood vast tracts of country. As a railway has been constructed from Rangoon up this valley, to Toungoo, the population will rapidly increase, and the land, becoming more valuable, will, doubtless, be reclaimed by drainage and embankment works. At present there are not more than 300,000 people in the British portion of the Sittang valley. A large amount of teak, and other timber, has been extracted from the forests neighbouring the branch streams, some of which are sixty to seventy miles in length, and navigable in the rains for many miles from their mouths.

The Irrawaddi discharges about four hundred and twenty millions metric tons of water during the year, and its greatest discharge in any one day was 5,000,000,000 tons, the lowest discharge in a day being 193,000,000 tons. The river is about 900 miles in length, the last 240 being in British territory. As far south as Akouk-toung its bed is rocky; further down it is sandy and muddy. New sandbanks are continually forming, and old ones being removed, which renders it necessary for the steamers plying between Rangoon, Mandalay, and Bhamo, to have a service of pilots upon the river. In the rainy season steamers and large boats enter the main river from Rangoon, by the Pan-Hlaing creek, but during the dry season they have to descend the Rangoon River for some distance, and proceed by different routes into the Irrawaddi. The tide is felt in the dry weather as far north as Hezdada, and rises 2½ feet at the junction of the Pan-Hlaing.

The Irrawaddi has its eastern sources in the forked prolongation of the snow-clad hills which separate the upper course of the Brahmaputra from that of the Salwen. Its most northern branches rise in about latitude 28° in the southern slopes of the Patkoi hills, and its Khyeng-dwen, or western, branch rises in the fork formed by the junction of the Patkoi and Shwé-Doung Gyee hills in latitude 27°. The Shwé-Doung Gyee continues southwards to Sagaing, a town nearly opposite Ava, and separates the eastern from the western branch of the river; throughout its length it is said to be auriferous, and many of its streams are washed for gold. Salt, amber, and serpentine, are mined for in this region, and a considerable traffic was once carried on between it and China. The Hookong Valley, which lies in the fork, was until the middle of this century occupied by Shans, but, owing to the constant extortions of the Burmese, they have retired amongst the Kakhyens into the neighbouring hills, where the Burmese officials dare not follow them.

The Khyeng-dwen is navigable for the largest boats plying on the Irrawaddi, and for steamers certainly as far north as Kendat, and most likely as far as the rapids which occur a little above the junction of the Ooroo river. At these rapids the cargo has to be transhipped into smaller boats for carriage to Maing Kwon and other places in the Hookong Valley. The Kubo Valley, about 140 miles in length, and from 10 to 15 miles in greatest width, having been a disputed territory between the Burmese and Manipurese, was handed over by us to the Burmese seven years after the conclusion of our first war with them in 1826. At the close of this war we not only annexed Aracan and Tenasserim, but precluded the Burmese from any further interference with the affairs of Cachar, Manipur, and Assam, which were then tributary to them. The teak forests in the Kubo Valley, as well as those in the Khyeng-dwen, have lately been worked by the Bombay-Burmah Trading Corporation, who have likewise been exploiting the forests in the Upper Sittang Valley. Our late war with Upper Burmah was, as you are aware, partly forced upon us by the arbitrary action of the king towards this company. The two small States of Thoung-thwot and Kalé, situated in the Kubo Valley, although subject to the Burmese, are still under the rule of their native princes. The lower portion of the valley in which Kalé is situated is drained by the Manipur river. The Manipur river has its sources in the hills surrounding the Manipur plain. The plain lies at an elevation of 2,500 feet above the sea, and is well watered, as notwithstanding the small rainfall in the plains of the valley, the surrounding hills, like those at the source of the Irrawaddi, intercepting the low-lying clouds brought up by the moonsoons, have an abundant rainfall. To the south of the Manipur plain the river escapes through a fearful gorge, which is believed never to have been traversed by man, and empties into the Khyeng-dwen in latitude 23° 12′.

The hill ranges to the west of the Kubo Valley are inhabited by Khyens or Chins, after whom the Khyeng-dwen river is named. These people are found in the hills to the west of the Irrawaddi, extending far down into our territory. Owing to our clement rule, they are gradually taking up land in the plains in British Burmah, and are giving up the hideous practice of tatooing a mask on the faces of their women. This custom is said to have arisen in order to destroy their beauty, and thus render them safe from the Burmese, who constantly raided their villages in order to carry the women into captivity. There are now upwards of 50,000 Khyens settled in our territory. The marriage custom of the Khyens is, I believe, unique. The girls are given in marriage by their brothers, not by their parents. When a girl is born she is especially assigned to one of her brothers, or, if she has none, to one of her father's sister's sons, whose consent has to be obtained by anyone aspiring to her hand, and who, after her marriage, must be treated with the greatest respect by her husband. If the husband visits the brother, he must take with him a present of *khoung*, a fermented drink; and should the brother visit the husband, he must take with him *khoung* and pork, or, if his circumstances are such that he cannot do this, he must make profound apologies. As a rule, girls are affianced early to one of their cousins, but the match may be broken off. In such a case the defaulter, if the man, has to give the girl five pots of *khoung*, a bullock worth thirty rupees, a pig three feet in girth, a spear, a fork, a bag, and a piece of ornamental cloth. If the girl breaks off the match, she has to give the man a brass dish worth fifteen rupees, a silk cloth and belt, each worth about five rupees, and a silk turban worth about eight annas.

A great deal of grain is grown in the lower portion of the Khyeng-dwen valley and likewise in that of the Ooroo, near the sources of which are the serpentine mines. The lower portion of the river passes through a broad, populous and fertile champaign, and presents an almost continuous horizon of palmyra groves, always in Burmah a sign of population and culture. From these there is a considerable manufacture of palm sugar. The sugar-cane is generally used by the Burmese merely for munching, but, according to Colonel Yule, a little sugar is made from the cane in the neighbourhood of Ava.

Most of the eastern affluents of the Khyeng-dwen are auriferous, and the country lying between it and the eastern branch of the Irrawadi, according to Colonel Yule, was anciently known as Sonaparanta, or the Golden Region. The Khyeng-dwen throws its waters into the eastern branch of the Irrawaddi by many mouths, the extreme outlets being twenty-two miles apart.

The eastern branch of the Irrawaddi is formed by the junction of the Nam Kiu and the Nam Yen, known by the Burmese as Myit Gyee and Myit Ngé, or the big and little rivers, in about lat. 26°; flowing southwards it receives the Mogoung river from the westward, in lat. 24° 56′. At this place the Irrawaddi is about 1,000 yards wide. Fourteen miles lower down it enters the first "defile," and is constricted to 150 yards in width, and in one place to even fifty yards. Small boats can ascend the "defile" as far as Kacho during the dry season, a small village in lat. 25° 20′, and about 1,000 feet above sea level. In the rains the rush of water stops all traffic. Emerging from the defile the Irrawaddi again expands, and receives the Taping river from the east, and continues its course, encircling several peopled islands, past Bhamo—which place, situated in lat. 24° 16′, was lately attacked by the neighbouring Shans and Kachens—to the second "defile," where at one place it is contracted to 200 yards in width. This "defile," unlike the first one, does not oppose any hindrance to navigation, and steamers pass through it to Bhamo, which is the entrepôt of trade for north-western Yunnan, and will certainly become, **under our rule**, a place of great importance, as it is the terminus of the shortest caravan routes into Western China.

For some time it was proposed by many of our officials to improve the caravan route by the construction of a wheeled road, and even a railway, but subsequent explorations have shown that although Bhamo, which is 430 feet above sea level, is only 250 miles distant in a direct line from Talifu, yet a railway would have to be 600 miles in length to connect these places. Four passes, between 8,000 and 9,000 feet above sea level, would have to be crested, besides many others of a somewhat lesser elevation. The cost of a railway connection by this route would be at least four times as great as that proposed by Mr. Colquhoun and myself, which, besides, has the great advantages of terminating at a seaport instead of at a town 840 miles up a river, of opening up the whole of central Indo-China, and of passing through a much more fertile and better populated region than would be traversed by the other route. Bhamo will, no doubt, ere long, be joined on by rail, *viâ* Mandalay, to our Rangoon and Tounghoo Railway, and subsequently to the Indian system at Dibrugah, thus tapping the whole of the passes leading from the west of the Shan States, and completing one of the schemes long ago proposed by my colleague and myself.

The third and last "defile" commences below Sampanago, and at times formed the southern boundary of the Shan States lying to the north. This "defile," which is considerably longer than the others, is more beautiful than grand; the banks are wooded to the water's edge, and slope down from the hills, whose steep sides form the valley. About half way through the "defile" is a small rocky island, which is connected in the dry season with the shore by a narrow spit of sand. In the bay thus formed lie enormous dog-fish, which are perfectly tame. Dr. Williams, in his book called "Through Burmah to Western China," relates that "As we drew near the island I asked the boatman to call the fish. He hesitated until assured that we had something to give them to eat, but at length slightly ruffled the water with his out-spread fingers, and called with a coaxing voice, tit-tit-tit-tit, when to our extreme astonishment, in less than half a minute, large mouths, from ten inches to a foot in diameter, rose up to the gunwale of the boat, gaping for alms. They were a kind of dog-fish, some of them at least five feet in length, and very broad at the shoulders. Twenty or thirty crowded to the side of the canoe, and though not clamorous, were ludicrously energetic in their begging; some of them rising so far out of the water as to lose their balance and topple back with a splash on their neighbours. So tame were they, that they allowed us to stroke their backs; some of them had patches of gilding on their heads." The "defile" ends a little above the village of Tshengoo Myo at the north of the Mandalay or Ava plain, which, as I have before said, is about 60 miles in length, and lies entirely on the east side of the river. To the east of Tshengoo are some fine caves in the limestone hills, which are about 100 yards in length. In hills to the west of the third "defile" coal is known to exist, and the famous ruby mines lie some thirty miles eastward. Veins of copper are worked in the Tsagaing range, and in the same range, near the village of Moway, are the famous marble quarries from which all the stone used in the sculptures of Gaudama found throughout Burmah has been obtained from time immemorial. The sculpturing and polishing of the images of Buddha are not carried on at the quarries, the stone for these purposes being boated down to Amarapura and Tsagaing, where the sculptors reside. Gold, silver, and copper are found in the hills south of the Myit Ngé and south-west of Ava.

Mandalay has been the capital of Burmah since 1857, but the capital was frequently removed during the first half of this century. In 1783 it was fixed at Amarapura, in 1823 at Ava, where it had previously been from 1364 to 1740, and from 1763 to 1783. Ava was destroyed by an earthquake in 1839, and the capital was removed to Monchobo, thence again to Amarapura, back again to Ava, and then to Mandalay. Ava, Amarapura, and Mandalay are only a few miles apart.

Mandalay, situated 3½ miles from the Irrawaddi, is laid out in a square, with a side of little more than a mile. It is surrounded by a brick wall 20 ft. high and 3 ft. thick, crenelated at the top, and backed by a rampart 20 ft. broad, which serves as a banquette for the defenders. There are flanking towers at intervals of about 200 ft., and at the angles of the square two contiguous towers form a bastion. The defences are entered by three gates on each side, protected by thick masonry traverses. At a distance of 60 ft. from the wall there is a deep, wet ditch, 100 ft. broad, crossed by five undefended bridges. Beyond this ditch there are no outworks. The palace, arsenal, magazine, and mint are enclosed in an inner central square, protected by a strong teak stockade, 20 ft. high. Inside this stockade there is a brick wall at 1,000 ft. distance, and again, an inner wall at the same interval. The population is between 60,000 and 70,000, and the number of houses about 12,000. The total population fringing the banks of the Irrawaddi between lat. 24 and our frontier may be taken as 250,000, and the total population of Burmah proper, lying between these latitudes—excluding the hill tribes—is most likely not more than a million souls. Various estimates give the number of villages on the banks of the river between Mandalay and our frontier at 230 to 261. Tsagaing, which lies opposite Ava, is of large extent, and is enclosed by a massive, decaying rampart. The hills behind it are nearly covered with pagodas, temples, and images, and long, winding staircases, some of the latter being about half a mile in length. Farther down stream you pass several large towns, notably Myingyan, which is a large mart for rice, and whence much cotton is exported; Yaynangyoung, the centre of the petroleum trade; Memboo, the terminus of the caravan road over the Aeng Pass, near which are some mud volcanoes; Magwé, Mengoon, and Minhla, which was taken by assault by our troops on the 17th of November.

Six miles after passing our frontier, which crosses the river in 19° 29′ 3″ and runs due east and west until it reaches the borders of Karennee and Aracan, we reach Myeday, our most northern advanced post. No custom duties are levied by the British at the frontier, and the Burmese custom duty of 5 per cent. upon exports and imports will no doubt cease now we have occupied the country. Twelve miles from the frontier we reach our military port of Thayetmyo, with a population of 16,000 souls; and about four miles to the north, on the eastern bank of the river, is Allanmyo, with about 6,000 inhabitants. The Irrawaddi district, which includes the portion of the basin of the Irrawaddi lying to the west of the river, has a population of about 1,200,000 souls; and the Pegu district, which includes the eastern portion of the basin, has about the same population. Notwithstanding the inhospitable character of the soil in the Thayetmyo district, and although the Upper Burmah officials jealously prevented the removal of women and children, cattle and household implements, from their country, this district annually received a large accession to the number of its inhabitants by immigration from the more fertile districts across the frontier. There the villages every year decreased in number, and if there had not been a considerable number of men living in some of the villages who were "wanted" by our police, the whole district would soon have become deserted, and merely the refuge o wild beasts, like much of the Shan country I passed through on my late journey. There being no waste low-lying lands available for rice cultivation, the immigrants betake themselves at once to *toungya*, or hill cultivation. Some settle down as cotton cleaners and coolies in the towns, whilst a few, after a year or two, adopt the wiser course of passing on to the richer districts lower down the river. The great bulk of the population in this district is of the pure Burman race, unmixed with Peguan blood as in the delta of the Irrawaddi, or with Shan blood as in the upper portion of Burmah proper.

The inhabitants of Burmah, owing to the excellence of the climate, are robust and healthy looking; they attain the average length of human life, and children especially thrive in the country. The infantile diseases, measles, chicken-pox, whooping cough, which cause such a mortality among the young in England, exist in Burmah in so mild a form as to excite little or no apprehension. The registration returns show that in Burmah the deaths of children under five years of age are in the proportion of 27·85 of the total deaths at all ages, whereas in England they are 40 per cent. Concerning the characteristics and peculiarities of the Burman, much need not be said. His virtues, which are many, and his failings, which are not a few, are much the same here as in every part of his extensive country. In British Burmah, as elsewhere, he displays much spasmodic energy and general laziness; much love of feasts and shows; much disregard of the sacredness of human life, and much tenderness for the lives of inferior members of the animal kingdom; much arrogance and inconsiderateness when placed in high position; and last, though not least, much general truthfulness, and amongst unsophisticated villagers, the very unoriental trait of being quite unable to tell a specious falsehood, a trait which is as honourable to himself as it is agreeable to those who have the government of his country. His occupations are cultivation on a small scale and petty trading. Actual poverty is almost unknown, but riches are never accumulated. If any individual, by a stroke of good luck, or by a most unusual exercise of thrift, should amass a few thousand rupees, he is sure to spend the greater portion of it in the erection of a pagoda or a monastery, or some similar work of religious merit.

The Burman is strongly distinguished from the Indian races by his love of sport and amusement, and his strong turn for the ridiculous. This has been not unjustly asserted to be due rather to the influence of the Buddhist religion as compared with Brahmanism than to the respective peculiarities of the races. In Burmah there is no caste to efface the impulses of our nature, and hinder everything in the shape of free and social intercourse. The Burman is in every way a marked contrast to the Hindu. Their women-folk mix freely in all social gatherings on perfectly equal terms, and form a very important factor in society.

It is noticeable in Burmah, where the monks are much more strict in their outward life and in the observances of their rules than in Siam, that the women are far more industrious and virtuous than the men; and I think this chiefly arises from the difference of the schools in which they are educated. The girls are kept at home, under the immediate supervision of their mothers, who teach them to be industrious, and train them from their infancy in the acquirement of common-sense, which has justly been called the most uncommon sense of all. Almost before they have left the breast they seem to become far-sighted little women of the world. Walk through any village or town, and you will see damsels squatting on the floor of the verandah, with diminutive, or sometimes large, stalls in front of them, covered with vegetables, fruit, betel-nuts, cigars, and other articles. However numerous they may be, the price of everything is known to them; and such is their idea of probity, that pilfering is quite unknown to them. They are entirely trusted by their parents from their earliest years; even when they blossom into young women, chaperons are never a necessity, yet immorality is less customary amongst them, I believe, than in any country of Europe.

The principal crops cultivated in the Thayetymo district are rice, oil-seed, cotton and tobacco. No less than sixty-one kinds of rice are known to the cultivators, more than half of which are of the hard varieties exported to Europe, and the remainder is the soft glutinous grain, which is preferred by the hill tribes. There are five different modes of raising a crop, namely:—

1. On the ordinary rice swamp-land, in low-lying plains, where the local rainfall is sufficient for the cultivation.

2. On lands which, though level, are so high that the drainage from them is too rapid for the growth of the grain without irrigation or damming of streams.

3. On land near the river bank which is submerged during the highest level of the river, and cannot therefore be planted until the last high rise of the river.

4. In *toungya* or hill clearings.

All the above are wet weather crops.

5. A hot weather crop, raised by irrigation-works, the water being obtained by damming the streams or by means of water-wheels. Many of these wheels are in use by the Shans in the Shan States, and likewise in the district to the west of Thayetmyo. They are made of a light framework of split bamboos, and are often forty feet in diameter. The banks of the Ma-htoon, where a view can be obtained of several of these spider-web machines

in ceaseless motion, their shafts humming loudly, and the water splashing and sparkling all over them, form a singular spectacle. The Irrawaddi at our frontier is about three quarters of a mile broad; thence it widens rapidly, and at Thayetmyo it is nearly three miles broad. Below this it contracts, and, flowing between bold and densely wooded banks, passes Prome with a width not more than three quarters of a mile. The Naweng river enters the Irrawaddi on the east bank, just to the north of Prome, and there is little doubt that the Hlaing river, which is the upper course of the Rangoon river, was at one time an effluent of the Irrawaddi, having its exit somewhere near the present mouth of the Naweng. The sources of the Hlaing, or Myit-ma-kha, now lie in the streams draining into the Engma swamp from the Pegu Yoma and those draining the west side of the Prome and Kholan Hills which lie between the swamp and the Irrawaddi. Many large plains, notably those of Engma, Pounday, and Shwé Doung, are under rice cultivation, the produce of which helps to "feed" the Rangoon and Prome Railway, and the large craft on the river. These craft, owing to the river running nearly north and south, can navigate up-stream with the help of their huge sails and of the south-west monsoon wind, even when the river is rushing down at the time of the highest floods. The lines of these boats are beautifully fine and graceful, but the absence of any keel gives them no hold of the water, and they can only sail with the wind. They carry a single square sail generally, but the largest boats used on the Irrawaddi have a peculiar mast, if it can be so called, consisting of two bamboo spars separated by the breadth of the boat at the bottom, and lashed together at the top, with cross bamboo ratlines, making it look like a gigantic ladder. The mainyard is formed in three pieces firmly spliced together, the centre of a tough wooden spar, and the outer pieces of bamboo; the whole is sometimes over 130 feet in length. This gives an enormous spread of canvas for the size of the vessel. The sail in these large boats is generally in three pieces, and I have sometimes seen smaller canvas carried in addition above the mainyard. The cloth used is very light country cotton stuff, like coarse unbleached calico. On these boats are erected houses, either of thin wooden planks or of matting, with thatched or matted roofs, and the steersman occupies a high chair of state, often elaborately carved, at the stern. The rowers generally row standing, the long oars being hung on pivots; in shallow water they use long bamboo poles, one end of which being stuck into the hollow of the shoulder, they push the boat forwards by walking along the sides, the whole weight of their bodies being thrown against the poles. Where the nature of the bank permits, they use long tracking poles.

The town of Prome has a population of about 29,000 inhabitants; Shwé Doung, 12,000; and Poungday about 7,000; and the district contains 275,000 country folk. Escaping from the hills bordering its eastern banks, below Prome the Irrawaddi enters the delta at Akouktoung, where the river is for the last time touched by spurs from the Arracan Yoma hills. From the high ground forming the toe of the last spur, a small embankment, six miles in length, has been raised, to save the land on the west of the river from the floods, and the Kyangyeen stream. Directly to the south of these streams the great system of Irrawaddi embankments begins, and extends with merely the breaks caused by the exit of the Bassein River from the Irrawaddi. The east bank of the Bassein River is likewise protected from floods by an embankment springing from the main embankment, about 70 miles in length. The length of the Myanoug section of the Irrawaddi embankment is 44½ miles, and the Henzadah section is 53 miles. These embankments have saved a vast area of ground which was formerly either subject to floods or heavily inundated in the wet season. The levées, however, particularly that along the Bassein river, have tended to throw the land on the other side entirely out of cultivation, having raised the level of the river during high floods, and thus forced a greater quantity of water over the banks. Owing to the narrowness of the stream, it will be most unwise to embank the west side of the Bassein River, but the Irrawaddi, being broad, will doubtless be embanked on the eastern side before many years. The inundation of the country, where not embanked, proceeds as follows:—The first showers of rain fill the numerous "engs," or depressions scattered over the country, and these gradually enlarging submerge the country before the turbid floods of the rivers have risen to a similar height (40 ft. above their summer level). In default of any effective drainage the ground adjoining the rivers being higher than the flooded interior, the ordinary rainfall is usually adequate to produce this effect, but the lowland skirting the hills receives in addition considerable, though irregular, supplies through streams which, pouring out from the hills, diffuse themselves over the country and lose themselves in plains. The muddy waters of the Irrawaddi (or other rivers) now rising, top their banks, but their course is soon arrested by the limpid waters of the plains, which oppose a perfect barrier to the spread over the low country of the river water, charged with sediment.

This regular and complete inundation of a whole country from one range of hills to another, not as an accidental occurrence, but as a yearly recurring event, affords one of the most singular phenomena of Burmah. With the exception of high knolls, standing up here and there, and a strip of high ground at the base of the hills, the whole country, with fields, roads, and bridges, is under water, from one to twelve feet or more in depth. Boats are the only means of locomotion for even a few yards. You sail across the country, ploughing through the half-submerged long grass, piloting a way through the clumps of brushwood or small trees into the streets of large agricultural villages, where the cattle are seen stabled up in the houses, sometimes twelve feet above the ground; the children are catching fish with lines through the holes in the floor; the people are going about in canoes on their everyday concerns, if it is only to borrow a cheroot from their next-door neighbour, in short, all the miseries and laughable *contretemps* sometimes pictured in the illustrated papers as caused by floods in Europe may be seen, with this difference, that everyone is so accustomed to them that they never create a thought of surprise.

Though in some ways unpleasant, this heavy monsoon is the great blessing and source of prosperity to British Burmah.

There may be too much or too little rain in certain districts to ensure a full good crop, but there is no fear of famine; nothing but an absolute blight passing over the whole land could produce it. The rice fields are not prepared, as in China, Italy, and elsewhere, in terraces carefully levelled for irrigation; but the grass and weeds are raked and pulled out with a huge harrow, and the young plants from the nurseries are set in the soft ground a foot deep in water. In a large plain there are, of course, inequalities, if even of only a few inches in the surface, so that if the waters subside too quickly, the crops on the higher ground are more or less injured. If the monsoon is a late and heavy one, the paddy plants in the low grounds are rotted, while the out-turn of the high land is increased. In ordinary years, the high lands being first planted, the danger in both cases is guarded against.

The Bassein district through which the river of that name runs, is chiefly occupied by Burmese, Aracanese, and Karens, there being about 200,000 of the two former and 87,000 of the latter, the total number of inhabitants being 350,000. The principal occupation of the people is agriculture and fishing, large lakes caused by "cut-offs" of the rivers, as well as the rivers and numerous tidal creeks, forming splendid fishing grounds. There are many large towns in the district; Bassein has 28,000 inhabitants, Ngatheingyoung about 3,000, and Leyinyitna 5,300. The Henzadah district, which is traversed by the main embankment, has 288,000 inhabitants, the largest towns in it, Henzadah, Kyangyeen, and Myanoung, containing respectively 16,700, 7,500, and 5,400 inhabitants. Most of the cultivated land is under rice.

Thongwa, the district lying to the south of that of Henzadah, contains 265,000 inhabitants, and is a country of tidal creeks and deltaic mouths; some of the plains are now under cultivation, and the land on the large island, on which is the district town of Maoobeng, is likely soon to be reclaimed by embankments.

Leaving the main river at Yandoon, which contains about 7,000 inhabitants, steamers during the rainy season proceed by the Pan Hlaing Creek to Rangoon. Yandoon extends for about three miles along both banks of the creek, and has sprung up almost entirely since 1852; in the Burmese time it was a small village of some hundred houses. It is the rendezvous of all the trading boats which run between the upper part of the valley of the Irrawaddi and Rangoon, and during the rains as many as 1,000 boats collect here and dispose of their cargoes, those from up-country to those from Rangoon, and *vice versâ*. The principal imports from up-country are wheat, grain, beans, pickled tea, oil, onions, garlic and silk; and the principal exports upwards, rice, husked and unhusked, piece goods, crockery, earthenware, tobacco and betel nuts. Small steamers occasionally run between Rangoon and Yandoon, making the trip, with a favourable tide, in one day.

Rangoon is the chief port and most important military station and town in British Burmah. It is situated on the east bank of the Hlaing, or Rangoon river, is supplied with admirable wharf and go-down accommodation, and steamers drawing 24 feet of water are able to proceed up to the town at high water. For some years the navigation was greatly impeded by the Hastings shoal, which formed a little below the town at the debouchure of the Pouzendoung and Pegu rivers into the Hlaing, but dredging has done much to improve the passage. Many of the handsome public buildings, as well as the characteristic architecture of the fine teak mansions in the town and cantonments, and most of the improvements of the port, are due to Mr. Henry Montague Matthews, who is now engineer-in-chief and manager of the railways leading northwards from Rangoon to Prome and Toungoo. The population of Rangoon, as might be expected, is very mixed, including Peguans, Karen, Shan, Aracanese Hindoos, Mahomedans, Chinese, and Eurasians, besides Europeans and other races. The town has doubled its population in the last twenty years, and in 1883 had upwards of 134,000 inhabitants. The rural inhabitants in the Rangoon district, at the same time, numbered 203,000 souls.

The Pegu river is about 180 miles in length, and rises in the Pegu Yoma range of hills. At its mouth it is about a mile broad. At neaps the tide is felt as far as the town of Pegu; and during the springs a "bore" ascends nearly as far. In the rains this river is navigable for river steamers as far as Pegu, but in the dry season only small boats can ascend to that town. It "taps" a country in which is found much teak and other valuable timber, and lower down flows through a considerable area of fertile rice lands. As far as the mouth of the new canal that has been constructed to connect it with the Sittang, above the influence of the "bore," it forms the main route to Shwaygyeen and other towns on that river. The town of Pegu has a population of about 6,000, and the Pegu district a rural population of 232,000.

Shwaygyeen, the head-quarters of a district of the same name, lies on the west bank of the Sittang river. A large cantonment was established there at the close of our second Burmese war, but it has for some years been reduced to a nominal garrison of a portion of a regimental wing. The town, which lies some miles to the east of the Rangoon and Toungoo Railway will, I trust, soon be connected with it, by the line proposed by Mr. Colquhoun and myself to connect Maulmain, the future terminus of the Burmah-Siam-China Railway, with the Rangoon and Toungoo line. The town of Shwaygyeen has a population of 7,500 souls, and the district one of 165,000.

To the east of the Sittang river, in lat. 17° 25′, at the end of the southern hills, lies the town of the same name; the population has been gradually dwindling away, owing to the sparseness of the cultivation in its neighbourhood and to its unfavourable situation, much of the passing traffic having been diverted by the opening of the Pegu Canal.

The great plain on the east of the Sittang, stretching as far as the western exit of the Salwen River, is subject to inundation as far west as Thatone, owing to the silting up of the mouths and lower channels of the creeks, and the throwing out of the coast-line. The creeks draining it are excessively serpentine in their course, and the tidal currents are therefore checked, and deposit more silt than would be the case if the creeks were straightened. Most of the plain might be reclaimed by straightening the courses of some of these streams, and draining others to the lower portions of the rivers. These are not nearly so liable to change as the sea-coast, which, owing to the courses of the rivers changing in the mud-flats, in places extends or else retires some miles in the course of a year or two. This plain, where reclaimed by cuttings, is very fertile, and would certainly receive the attention which it deserves if the railway from Martaban, *viâ* Sittang and Shwaygyeen, to join the Rangoon and Toungoo line, were decided upon. If these plains are reclaimed, the railway could not fail to be the most profitable one in Burmah.

The Beeling river rises in the maze of mountains that separate the Salwen from the Sittang, and until it enters the plain to the south of Beeling, has the character of a mountain torrent. A "bore," similar to that in the Sittang, rushes up the river for many miles at spring tides in the dry weather.

Thatone, the oldest capital of the Peguans, was deserted by them in a body, when Alaungpra reconquered Pegu in the middle of last century. They fled to Siam and settled there, taking their records along with them. The town, although now twelve miles from the sea-shore, as late as A.D. 600 was a sea-port, and ships traded thence to the Coromandel Coast and Ceylon. It now contains about 4,000 people with a district population of about the same number. Among the large towns lying between it and Martaban, may be mentioned Ying-yeng, Palat, and Poung. Martaban lies at the junction of the two mouths of the Salwen, opposite to the sea-port of Maulmain. Separating these two places from the sea, and stretching nearly as far south as Amherst, is the fertile island of Beloogyoon. Martaban, although now only a small village, was formerly the capital of a large kingdom often in dispute between the Shans, the Burmese, and the Peguans.

Maulmain is situated at the confluence of three large rivers, the Salween, the Gyne, and the Attaran. It contains about 53,000 inhabitants, and its district, called the Amherst district, upwards of 300,000. The cultivation in the interior lies chiefly along the banks of the main streams, the country inland being generally subject to heavy inundation. No embankments exist along the rivers, and very little has been done for this portion of the country since our occupation of it in 1826. Even the fine port of Maulmain is allowed to deteriorate for the want of sanction for the removal of a sand bank that partially blocks the principal channel seawards. A road has been constructed from Maulmain in the direction of Tavoy, and was intended to be carried inland some distance from the coast, to connect Maulmain with that town for military purposes. But the country through which it was to pass was found to be nearly deserted, except by wild beasts, and the road has been allowed to end in the jungle. A branch road has, however, been made to connect it with Amherst, a town on the sea coast at the mouth of the Salwen, which is the seaside retreat of inhabitants of Maulmain, and for some time after the cession to us of Tenasserim was the capital of that province.

The journey by steamer down the coast to Tavoy and Mergui is delightful in the north-east monsoon, when the sea is generally calm on the eastern coast of the Indian Ocean. The whole face of the country, hill and dale, except where cleared for cultivation, is densely clothed with luxuriant vegetation, and the coast-line is studded with islands.

The town of Tavoy is situated some thirty miles from the mouth of the river of the same name, and is separated from the coast by the river and a narrow range of hills, across which the European officials trudge to their sea-resort of Momegan, where they erect small temporary bungalows and enjoy the sea-bathing. The town is neatly laid out, and the roads are generally kept in excellent order; the town has about 13,000 inhabitants and the district, which, with the exception of the plain along the river, is very hilly, 85,000. Three roads lead from Tavoy into Siam, and our telegraph line is connected, *viâ* this place, with that of the Siamese at the frontier.

The last town along the coast of British Burmah of any importance is Mergui, which is the head-quarters of a district of the same name. It is situated on an island in the principal mouth of the Tenasserim river, which falls into the sea about two miles to the north and one to the south of the town. Mergui contains 8,600 inhabitants, composed of mixed races, Peguans, Burmese, Malays, Bengalis, Madrassis, Siamese and Chinese. In former years it was a penal settlement to which convicts from Bengal were transported. The best servants in the place are Thugs, who have their crime indelibly tatooed on their foreheads.

Amongst the mountain ranges of this district there are several plains of great extent, possessing a rich alluvial soil; two of these are about 100 miles in length. There are several passes leading over the hills into Siam. Coal is found in one of the valleys, and gold, copper, iron, manganese, and tin occur in the hills. Elephants and rhinoceroses are found in the hills and low plains in much of the wild country to the south of Amherst and Tigers; leopards and cheetah are plentiful, as well as several small kinds of deer and wild hog. Turtle eggs are collected on the sand banks, and *bêche de mer* are brought to Mergui, whence they are exported to the Straits Settlements. Edible bird's nests are found on Tavoy Island and other islands in the Archipelago, and are likewise exported for Chinese epicures at the Straits Settlements.

The climate of Mergui is remarkably salubrious. The great heat which its tropical situation would otherwise involve during the months of March, April and May is moderated by the land and sea breezes which follow each other alternately day and night. North-easterly and north-westerly winds prevail during the winter and spring months. For the remainder of the year southerly and westerly winds are the most common. It often happens in the rainy season that storms recur daily for several days, but on each occasion an hour earlier or later than on the previous one. The atmosphere is very humid, and the rainfall averages 165 inches in the year.

Only one half of the area of British Burmah is culturable, and only one-seventh of that half is under cultivation. Taking the present population at 4,000,000, there is room for 24,000,000 more without overcrowding the province. Even now about 1,000,000 tons of rice are exported every year, after feeding the population, cattle, and elephants. It is therefore certain that if all the reclaimable waste lands were brought into tillage, Burmah would be unrivalled as a granary.

The population of British Burmah has increased from 2,747,141 in 1872, to 3,736,771 in 1883. In the same interval, the public expenditure in the province has risen from £779,513 to £1,493,702. Trade has more than kept pace with the advance of population and revenue, as the following figures will show:—

	1874.		1883.
Imports....	£1,859,095	..	£3,772,887
Exports....	3,480,407	..	7,039,525
Total....	£5,319,520		£10,812,412

The relative increase of the imports is somewhat greater than the increase in exports, but with the balance of trade so strongly in favour of the province, its capacity as a consumer of British manufactures is very imperfectly measured by the actual value of the imports. Again, the comparatively small amount of those imports demonstrates conclusively that Upper Burmah has acted as an effectual and insurmountable barrier between the port of Rangoon and those illimitable commercial requirements of Western China and the Shan States, which it has been the hope of the Government and merchants alike to ascertain and to satisfy. Rice represents 80 per cent. of the total exports. The other chief exports are teak, cotton, jade, petroleum, spices, tobacco, hides, horns, ivory, india-rubber, shellac, cutch, and drugs. Of these, teak forms 7 per cent. of the total exports, and cotton 2½ per cent.

The statistics of the province show that one of the chief wants is population, a want which our connection with India and China would make it easy for Madras, Bengal, and China to supply, thus adding materially to the producing capacity and general prosperity of the province. In the ten years ending 1883, the State outlay in British Burmah was £11,228,282, or an average of £1,122,828 per annum. During this period the revenue rose from £1,565,186, to £2,702,086, an improvement of £1,136,000 between the first and last years of the decade. This is a result which seems to prove that the State could not, in its own interest, pursue a more wise or a more profitable domestic policy in the case of British Burmah, than to devote to the province special funds to be employed in opening out the country, in the extension of its railways, the improvement of its new water communications, and the construction of carefully selected roads to feed the railways and the river channels.

Our conquest of Upper Burmah, which has been so happily concluded within the past few days, will place the Burman Shan States under our protection. We can now drive the iron horse from India down the valley of the Irrawaddi, and *viâ* Maulmain to the very gates of China without any political impediment. Mr. Colquhoun and I, solely in the interests of our national commerce, have given our services gratuitously during a series of years in promoting this connection of India and China. We have performed our part of the work as pioneers, by exploring and reporting upon the country requiring examination; we have shown that railway connection between India and China is practicable at no excessive outlay, that the country is well worth opening out, and that the connection of Siam and China with Burmah and India will open out to British commerce the rich but land-locked interior of Western China, as well as develop and civilise the whole of Central Indo-China.

It now remains for the British Government and our mercantile community to do their part, and we earnestly trust that the present opportunity for permanently increasing our commerce and strengthening our position in Asia may not be allowed to pass away.

[A map to illustrate Mr. Hallett's paper will be issued as a supplement to the next number of the *Journal*.]

DISCUSSION.

Mr. W. R. Colquhoun said he had had the good fortune to be associated with Mr. Hallett for many years, having, in fact, served his apprenticeship as an engineer under him, and he had had the opportunity in Burmah of seeing his great capacities whilst in charge of large engineering works there. Mr. Hallett devised many important schemes for the development of the country, but he feared some of these still lay in the Government pigeon-holes to which they had been consigned. On returning from his recent journey across Southern China, the English Chambers of Commerce, seeing the importance of the development of communication between Burmah and China, subscribed a large fund for the purpose of exploration. At the last moment he was not allowed to take command of the expedition, but Mr. Hallet, came forward and offered his services gratuitously, and he had recently laid before the Royal Geographical Society and the Chambers of Commerce his interesting and valuable reports. Mr. Hallett had fully brought out the importance of Burmah *per se*, which was clearly shown by the enormous increase during the last ten years of both revenue and population. He wished, however, to say a word or two on a much more important aspect of the question, viz., the importance of Burmah to Great Britain, as a country lying between the two most populous empires in the world, India and China. Burmah had hitherto, owing to the anarchy and misrule which had prevailed there, barred the way to communication between those two countries. The importance of developing communications between India and Burmah and China was simply enormous; no other question at present before the country, whether commercial or political, at all approached it. With a country like England, a vast workshop, and a rapidly increasing population, and with foreign competition hemming it in on every side, and hostile tariffs barring us from our old markets, every thinking man must see that in this enormous market of China lay the future for the development of English commerce. He had lately had the opportunity of bringing this question before the leading Chambers of Commerce, first in London and afterwards in various large provincial centres, and he was glad to find that its importance was appreciated. Latterly he had been able to address those who were most vitally interested, the working men themselves, and he was exceedingly pleased to be able to say that they seemed to take more interest and to grasp the question even more quickly than those above them in position. If only a few men who were in earnest in this matter, and who had the facts at their fingers' ends, would go amongst these men and talk the question over with them, there would be a much more just appreciation of the value of foreign affairs, and a more statesmanlike policy might now be expected to guide the movements of whatever Government was in power. The indifference in this country a few years ago to the whole question of our Colonial and Eastern markets was simply appalling. Some three or four years ago, when he went into some of the largest industrial centres, he was repeatedly asked by wealthy merchants of high position—what was the use of our colonies and of these new markets? It was very difficult to come down to the intellectual level necessary to answer such questions. The last few years of adversity and growing competition had whetted the intellect of the country, however, and he now found considerable interest taken in the question everywhere. Turning to the political aspect of the question, he had that afternoon had an opportunity of addressing the Royal United Service Institution on the political value of the friendship of China to England. The Russian question—which might, perhaps, be again raised sooner than many people thought for—seemed to him an exceedingly simple one. Russia had for years, at enormous sacrifices, been making her way across long stretches of barren waste, not for the mere pleasure of overcoming those difficulties, but to reach two objectives which were always in her mind's eye—to place herself in a position contiguous to the two richest and most populous countries in the world, India and China, from whence she would be in a position at any time to menace those empires, and get what she wanted elsewhere. To avoid this constant menacing of India and China, it was the true interest of Great Britain not only to develop communication between India and China with a view to commercial and industrial development, but also towards building up a political alliance, based not on paper treaties, but on permanent interests, and cemented by constantly growing commerce. Mr. Hallett and himself had advocated with all their power the development of railway communication between India, Burmah, and China, and after laborious exploration and study had found that a practical line existed. The advantages of this railway it was not necessary to discuss in that room, but considering what had been going on for many years in America—how men had the courage there to thrust forward enormous lengths of railway across desert lands, trusting that as they pushed forward these lines population would follow,—it was strange that Englishmen had not sufficient faith to push forward 600 miles of railway into one of the most populous countries in the world. He trusted recent events in Burmah would consolidate the empire in India, and bring security and order to the frontiers of the neighbouring friendly powers, Siam and China.

Sir GEORGE CAMPBELL, K.C.S.I., M.P., said he had not been in Burmah, and having no special knowledge of the country, he naturally desired to learn as much about it as possible. He had considerable doubt, however, whether the true route to China lay in that direction. He thought the natural communication was by sea, and up the rivers; the River Kinsha being, he believed, a tributary of the Yangtsi Kiang. China was not limited to Yunnan, though that was a considerable province, but as far as he could gather, the richest portion of it was not on the side towards India. It was, of course, very desirable to have communications, but he believed the physical difficulties were so great, and there was so much risk of political difficulty, that it would not be wise to be too sanguine in the matter.

Mr. TRELAWNY SAUNDERS referred to the fact that ever since England had occupied British Burmah, that country had never wanted strong and devoted advocates for opening up the territory to British industry and capital, but hitherto without much success. Captain Spry, who was connected with the conquest of British Burmah, on his return devoted his life and fortune to exactly the same work Mr. Hallett and Mr. Colquhoun were now doing. The country seemed to exercise a singular influence on all who visited it, and he could not resist evidence of that kind. British Burmah had exercised a considerable influence on India, and had, in fact, contributed so much to her finances as to lead to the complaint by Mr. Hallett that more money should be spent on Burmah herself. For the sake of those who were not acquainted with the subject, he would point out on the map the British possessions in that part of the world. Between British Burmah and Assam lay the kingdom of Burmah, the people of which had for centuries been ruled by monarchs scarcely above the condition of lunacy, a condition showing itself in the most cruel and debased forms. He believed for centuries only one man had shown himself at all worthy of the position he occupied. There could not be a question that bringing the whole of the country under British rule would be infinitely to the advantage of the inhabitants themselves, who were ready to welcome our sway, and would also contribute immensely to the opening of markets for English commerce. He did not admit that even so important a consideration as the employment of our mill hands should altogether be the guide in dealing with other countries, but when it was found that the exercise of British rule operated, as it had in India, to the vast advantage of the countries so governed, then we could have little doubt as to the direction in which our responsibilities and duties lay. We were bound to feed our people at home, and to go forward in the civilisation of the world, and in extending the advantages we enjoyed wherever it fell properly to our hands to do so. He had no patience with the peace party and with the pietists, who set themselves up as superior to Providence itself, in refusing to exercise our influence and enterprise when the opportunity presented. What our forefathers found it necessary to do for promoting the prosperity of the country, should be emulated at the present day. He was an advocate for the annexation of Burmah, and hoped that all present would, as far as possible, promote that idea, not only for the benefit of English trade, but also in the interest of the Burmese themselves.

Mr. THOMAS CHRISTY, who had resided for some years in China, said it must be interesting to the meeting to know that from Akyab it was not at all unusual for ten or twelve vessels to sail for China. In fact, the district from Rangoon to Akyab really supplied the Chinese with rice, and if the rivers got frozen so that it was impossible to get the rice up, the people died by thousands in the interior. It would be exceedingly important to open up communication from the south up to the back of China, whilst the same line would afford the means of bringing down from the interior valuable drugs, wood, and tea, which could be shipped to England.

MR. MARTIN WOOD said that mention of Captain Spry's name reminded him that he advocated a somewhat similar plan to that now brought forward, but he understood that his proposal to carry a railway across to Yunnan had been by general consent abandoned. Mr. Colquhoun had spoken of a railway 600 miles in length, but he understood that when he spoke at the London Chamber of Commerce, his plan was to cross from Maulmain to Siam, which would be only two or three hundred miles. He thought the proposal of Mr. Hallett for getting into Assam by the north-west possessed very formidable engineering difficulties, and the proposed line from Maulmain and Martaban round to Rangoon would have to cross all the watersheds, and be somewhat expensive. He was sorry Mr. Saunders did not a little ballast his eloquence by saying how all this grand expansion was to be accomplished, and at whose expense. Mr. Colquhoun also used the expression, the Burmese question, but did not define what the question was, or say who was to provide the ways and means. If he appealed to the mercantile public, by all means let them find the capital, and do it at their own risk.

Mr. COLQUHOUN said he was astonished to find a man holding the position of Sir George Campbell speak in such discouraging terms of the probability of developing communication from Burmah to China, and also at the grounds on which he based his opinion. One statement he had made was in direct contradiction of all the evidence yet put forward by travellers and missionaries who had crossed south-western China, viz., that the most prosperous part of Yunnan lay in the basins towards the Yangtsi Kiang; and that this region would be most naturally reached from the Chinese seaboard. Exactly the reverse was the case. In the journey he made from Canton across southern China, one of the points he established was that the richest part of Yunnan was the southern portion, where lay all the large plains, cities, and towns. The northern part was barren wild upland, with little means of communication and very few towns or even villages. With regard to the enormous physical and political difficulties in developing communication, he did not know whether Sir George Campbell was aware of the precise line proposed; but he seemed to be thinking of the enormous hill ranges in the north. Any communication in that direction was exactly what Mr. Hallett had been trying to show would be impossible; but if he referred to the route proposed by Mr. Hallett and himself, starting from Maulmain and crossing into Siam, it ran over an easy plateau at an elevation of 2,000 feet into Siam, and from thence it might be continued to the Cambodia river, crossing no height greater than 550 ft. to within 200 miles of the Chinese frontier. The only political difficulty which could exist, considering that one portion ran through the British territory and the rest through Siam, must lie either with ourselves or with that country, and the Siamese were well known to be not only progressive but very friendly towards England, and desirous of having the railway made. The only possible difficulty lay in the eventual extension to China itself, but that was not proposed to be done at present. As China was on friendly terms with England, and as no step in this direction or in the settlement of Burmah would be taken without having a cordial and clear understanding with China, he did not see why the bogey of a political difficulty need be manufactured. If the expansion of commerce was only to be carried out in the manner suggested by Sir George Campbell, he could not look forward with any confidence to the future of this country. It was an axiom to men having any knowledge of the subject that the numerous treaty ports along the coast, some nineteen now, had not by any means realised the expectations formed at first. Instead of enabling us to reach the interior, they had only given access to the merest fringe of that mighty empire. There were only two waterways, the Yangtsi-kiang and the Canton rivers in the south, and besides those there were no means of getting at the interior. He must decline to answer the question put by Mr. Wood as to the financial aspects of the railway; that question had been thrashed out thoroughly at the various Chambers of Commerce throughout the country, as well as the physical difficulties.

THE CHAIRMAN, in proposing a vote of thanks to Mr. Hallett for his paper, and also to Mr. Colquhoun for the interesting information he had given, said it would be difficult to exaggerate the value of the services which those gentlemen had rendered to the mercantile community by their explorations of this territory lying between India and China, and by setting before the English public a new Imperial policy which might be carried out by England in the East with the greatest advantage. He had recently returned from an electioneering campaign amongst one of the busiest industrial communities of the North, and could thoroughly confirm what Mr. Colquhoun had said as to the deep interest felt by the working men in those districts, which were suffering most severely from the depression of trade, in the opening out of this new field for commerce, and he was quite certain they would not readily forgive any Government who did not give them the fruits of the recent military enterprise, which had been conducted so successfully. Sir George Campbell had conjured up a good many difficulties, but these difficulties were always heard of when any scheme was brought forward in the first place. He could not but recollect the indifference and neglect with which Mr. Stanley was treated in this country, when he came over and told us about the Congo, but how many of his then traducers would be delighted now if we had kept control over the great waterway into the heart of Africa? That was a fair illustration of the way in which men who came to tell of new enterprises were neglected. The public was much more willing to listen to them now, when suffering from depression of trade, than in the days of prosperity. He was glad to see that Messrs. Hallett and Colquhoun had been very successful in propagating their views. They might indeed be said to have put in motion the Government arms which had succeeded in breaking down for the time the barriers that interposed between India and China; barriers it was to the interest of this country should not be raised up again. The celebrated buffer theory did not apply in the case of Upper Burmah. The object of a buffer was that it should be of sufficient strength and elasticity to resist the violent approach of a body moving with considerable force and velocity. That was the object with which certain statesmen proposed that Afghanistan should be kept as an independent country between Russia and India. He would not offer an opinion whether that policy was likely to be successful in that direction or not, but would point out that, as regarded Upper Burmah, a buffer was the very thing which was not required. India and China were anxious to rush into one another's arms, and enjoy all the benefits of mutual intercourse, and, therefore, the last thing they wanted was to have a State interposed between them. These considerations must well be borne in mind when settling the destiny of the country which had just been conquered. With regard to the financial aspect of the question referred to by Mr. Martin Wood, the first step had been taken towards finding capital by extending civilisation over that country. Putting down barbarism and lawlessness was the first means to obtain capital. They had given the inhabitants good government, and it was absurd to suppose that wealthy India and England would not readily find capital for carrying out these railways, which would offer the shortest entrance into the great Empire of China.

The vote of thanks was carried unanimously, and briefly acknowledged by Mr. Hallett.

Miscellaneous.

THE VALUE OF LANDED PROPERTY IN FRANCE.

Consul Peixotto of Lyons, says that the value of landed property in France, as ascertained after four years' patient investigation by the Government, is reported to amount to as much as £3,682,400,000, and this is exclusive of the value of the buildings which, if added to that of land, would probably increase the total value to a sum exceeding £5,514,200,000. The net revenues obtained from landed property is £104,268,000. By comparing the figures of the revenue with those of the market value, and separating each according to the nature of the property, it is found that, taken together, the revenue from rural property, with a valuation of £73 per hectare, is about forty-two shillings per hectare. The rural property in France is divided into six categories, viz., superior lands, such as orchards, hemp-fields, and gardens; arable lands properly so-called; pasture, meadow, or grazing lands; vine lands; timber, and lands or commons more less cultivated. The superior lands extend over an area of 1,716,650 acres, having a market value of £153,958,000, and yielding a net revenue of £4,644,000. The arable lands cover a surface of 64,000,000 acres, out of a total area of 123,000,000 acres of rural property, yielding a net revenue of £60,312,000. The meadow or pasture lands are even more valuable. Of these there are, at the present time, 12,345,750 acres, rendering an income of £19,820,000, representing a market value of £595,064,000. In spite of the ravages of the phylloxera, the vines of France still show an important production, 5,730,400 acres of land being devoted to vineyards, and the net revenue derivable from them being £12,124,500, and thus it is shown that this description of property is the most productive of all rural investments. The timber lands of France cover an extent of 20,741,000 acres, and their market value exceeds £251,789,000, and the net revenue derived is £7,596,000. Meadows and pastures cover a superficies of 16,566,000 acres valued at £55,890,000, and yielding a revenue of £1,648,255. Of late years there has been a considerable increase in the value of unproductive lands in France. The inquiries on this subject which have been recently made by the French Government, have resulted in the fact that, since 1879, there have been cleared 1,406,155 hectares, or nearly 3,500,000 acres, which are at present classified among arable and timber lands, and vineyards, and which under recent laws are so taxed.

FOODS OF BARBARY.

Among the animal foods consumed in these districts, the first place must be accorded to the flesh of goats and kids; next follow mutton and beef. The tongues of camels are smoked and salted for exportation, principally to Italy, but do not seem to be an article of local consumption. Fowls of the Spanish breed are reared in immense number. The tunny, pilchard, and herring are among the chief fish taken on the coast, together with a kind of shad called "Mogador herring." The catching of the *shebbel*, or "Barbary salmon," a species of shad, is a great industry on all the principal river mouths, and vast numbers of the fish, weighing 5 lb. to 15 lb., are dried and salted. Much dried fish is exported to Greece. Another fish not uncommon in the shallow waters on the coast is a species of grey mullett (*Mugil cephalus*). Under the name of *boutargue* or *botargo*, a kind of caviare is prepared from the roe of the mullet and spawn of the tunny. The preparation is as follows:—Fish whose ovaries have arrived at maturity are opened, and their entire roes are removed, cleaned, pressed between heavily loaded planks for a week, then washed with brine and again pressed. Another method consists in salting the roe, bruising it into a cake, which is then smoked and sun-dried. The best brand of *botargo* is said to be prepared in Tunis; its consumption is very general throughout the Mediterranean. A rough-scaled, cod-like fish, called *aslimsah*, is plentiful on the coasts, and included in the native dietary. The fishing appliances in use are capable of much improvement.

The staple vegetable foods are barley, wheat, beans, maize, olives, grapes, and dates, the last-mentioned being by no means the least important. Under the name of *nabu*, jujube berries, the fruit of the sidra tree (*Zizyphus orthocanthus*), are commonly sold in the markets of Morocco, and eaten in large quantities. The national dish in Morocco is *couscousso*, made of granulated wheaten flour. In times of famine the tubers of *Arum arisarum*, called *irene*, are dug up washed, sun-dried, and ground between hand millstones; the meal is then cooked by steam like *couscousso*. The poisonous principle is not always removed effectually, and causes severe abdominal pain. The garden radish (*Raphanus satinus*) is eaten under the name of *fijjil*.

Correspondence.

TECHNICAL ART TEACHING.

Mr. G. N. Hooper writes to say that the number of students in Germany under technical art instruction was stated by him, in the discussion on Mr. Hulme's paper, to be 100,000, and not 10,000, as printed in the *Journal* (see *ante*, p. 72, col. 1). His authority is the *Chamber of Commerce Journal* for April, 1885, where the statement is given on the authority of the *Bourse Lyonnaise*.

General Notes.

Wine-growing in Italy.—Italy, with an area of 296,322 square kilometres, and a population of 27½ millions, has 1,879,109 hectares (4,641,400 acres) of vineyards, which produce annually 27,106,574 hectolitres (596,344,628 gallons) of wine, which, calculated at an average price of 25 lire per hectolitre (nearly 11d. per gallon), would amount in value to 677,664,350 lire, or £27,106,574 sterling. In Europe, Italy ranks third in importance as a wine-growing country, following immediately after France and Spain.

CULTIVATION OF FLAX IN RUSSIA.—The *Central Blatt für Textil Industrie* reports that the complaints of the inferior quality and defective yield of Russian flax within the last few years, have led buyers in other countries to represent to their various Governments the advisability of stimulating domestic flax culture by means of subsidies. The sale of Russian flax has been to some extent prejudiced in foreign countries by the importations of Indian and Italian flax. Efforts are now being made, however, in Russia to place this important branch of national industry upon a better footing, by organised measures for promoting the improvement of the quality, and the general development of flax culture.

MEETINGS OF THE SOCIETY.

ORDINARY MEETINGS.

Wednesday evenings, at 8 o'clock :—

At the meetings after Christmas the following papers (among others) will be read :—

"The Treatment of Sewage." By Dr. C. MEYMOTT TIDY.

"Calculating Machines." By C. V. BOYS.

"The History and Manufacture of Playing Cards." By GEORGE CLULOW.

"Domestic Electric Lighting." By W. H. PREECE, F.R.S.

"The Scientific Development of the Coal Tar Industry." By Prof. R. MELDOLA, F.C.S.

"The Experiments with Lighthouse Illuminants at the South Foreland." By E. PRICE EDWARDS.

"Machinery in Mines." By HENRY DAVEY.

Artistic Bronze Carving." By GEORGE SIMONDS.

FOREIGN AND COLONIAL SECTION.

The Meetings of this Section will take place on the following Tuesday evenings, at Eight o'clock :—

January 26; February 16; March 2, 23, April 13; May 18.

APPLIED CHEMISTRY AND PHYSICS SECTION.

The Meetings of this Section will take place on the following Thursday evenings, at Eight o'clock :—

January 28; February 11, 25; March 11; April 8; May 13.

INDIAN SECTION.

The Meetings of this Section will take place on the following Friday evenings, at Eight o'clock :—

January 22; February 19; March 19; April 2; May 7, 21

CANTOR LECTURES.

The First Course will be on "The Microscope." By JOHN MAYALL, Jun.

December 21.

The Second Course will be on "Friction." By Prof. H. S. HELE SHAW.

January 18, 25; February 1, 8.

The Third Course will be on "Science Teaching." By Prof. F. GUTHRIE, F.R.S.

February 15, 22. March 1.

The Fourth Course will be on "Petroleum and its Products." By BOVERTON REDWOOD, F.C.S.

March 8, 15, 22, 29.

The Fifth Course will be on "The Arts of Tapestry Making and Embroidery." By ALAN S. COLE.

April 5, 12, 19.

The Sixth and Concluding Course will be on "Animal Mechanics." By B. W. RICHARDSON, M.A., M.D., F.R.S.

May 3, 10, 17, 24, 31.

JUVENILE LECTURES.

The Two Juvenile Lectures on "Waves" will be given by PROF. SILVANUS P. THOMPSON, D.SC., on Wednesday evenings, December 30th, 1885, and January 6th, 1886. Special tickets are issued for these lectures.

ADMISSION TO MEETINGS.

Members have the right of attending all the Society's meetings and lectures. Every member can admit *two* friends to the Ordinary and Sectional Meetings, and *one* friend to the Cantor Lectures. Books of tickets for the purpose have been issued to the members, but admission can also be obtained on the personal introduction of a member.

MEETINGS FOR THE ENSUING WEEK.

MONDAY, DEC. 21...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. (Cantor Lectures.) Mr. John Mayall, jun., "The Microscope." (Lecture V.)

Geographical, University of London, Burlington-gardens, W., 8½ p.m. Major A. W. Greely, "Arctic Exploration with reference to Grinnell Land."

Actuaries, The Quadrangle, King's College, W.C., 7 p.m.

Medical, 11, Chandos-street, W., 8½ p.m.

Asiatic, 22, Albemarle-street, W., 4 p.m.

London Institution, Finsbury-circus, E.C., 5 p.m. Mr. W. R. S. Ralston, "Russian Village Life."

TUESDAY, DEC. 22...Civil Engineers, 25, Great George-street, S.W., 8 p.m. Mr. John Milne, "Construction in Earthquake-Countries."

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FRIDAY, DECEMBER 25, 1885.

All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

NOTICES.

MAP OF BURMAH.

With the present number of the *Journal* is issued, as a supplement, a map of Burmah and the adjacent States, to illustrate Mr. Holt S. Hallett's paper on "Burmah, present and future," printed in last week's number.

JUVENILE LECTURES.

All the tickets for these lectures having now been disposed of, the issue is stopped. As all the available accommodation will be required for those members who have applied for tickets, it will be understood that no member can be admitted without a ticket.

CANTOR LECTURES.

Mr. J. Mayall, jun., delivered the fifth and last lecture of the course on "The Microscope" on Monday evening, 21st inst.

A vote of thanks to the lecturer for his interesting course of lectures was carried unanimously on the motion of the Chairman. Thanks were also accorded to Mr. Frank Crisp, the Royal Microscopical Society, and the manufacturers who had kindly lent valuable instruments to illustrate the lectures and for exhibition in the Library.

Proceedings of the Society.

THE ALBERT MEDAL.

The Council of the Society of Arts attended on Monday, the 21st inst., at the Lambeth Pottery, to meet H.R.H. the Prince of Wales, who visited the Pottery for the purpose of presenting to Mr. Henry Doulton the Albert Medal, awarded "in recognition of the impulse given by him to the production of artistic pottery in this country."

The presentation took place in Messrs. Doulton's show-rooms, Albert-embankment, at noon.

The members of Council present were Sir Frederick Abel, D.C.L., C.B., F.R.S , Chairman; Mr. W. Anderson, Mr. Francis Dillon Bell, K.C.M.G., Sir Frederick Bramwell, F.R.S., Mr. Alfred Carpmael, Mr. Brudenell Carter, F.R.C.S., Lord Alfred S. Churchill, Mr. B. Francis Cobb, Mr. Vicat Cole, R.A , Mr. T. R. Crampton, Sir Philip Cunliffe-Owen, K.C.M.G., C.B., Professor Dewar, F.R.S., Captain Douglas Galton, D.C.L., C.B., F.R.S., Colonel A. Hamilton, R.E., Sir Villiers Lister, K.C.M.G., Mr. J. M. Maclean, M.P., Mr. George Matthey, F.R.S , Mr. W. G. Pedder, General Sir Henry Ponsonby, K.C.B., Mr. W. H. Preece, F.R.S., Sir Robert Rawlinson, C.B., Mr. Owen Roberts, and Lord Sudeley, with Mr. H. Trueman Wood, Secretary, and Mr. H. B. Wheatley, Assistant-Secretary.

His Royal Highness was received by Sir Frederick Abel, Chairman of the Council, and the members of Messrs. Doulton's firm.

Sir Frederick Abel, in a few words, introduced Mr. Henry Doulton, to whom the Society of Arts had awarded the highest honour in their power to bestow, for the prominent services he had rendered to the country at large in the advancement of art.

H.R.H. the Prince of Wales said:—Ladies and gentlemen,—It affords me great gratification to present, on this occasion, the Albert Medal to Mr. Henry Doulton. By the wish and unanimous agreement of the Council, and with my approval as having the honour of being the President of the Society of Arts, this medal has been awarded to you, Mr. Doulton, in recognition of the impulse given by you to the production of artistic pottery in this country. It would have been my privilege to have handed you this medal at Marlborough-house, but I felt sure that it would be more gratifying, not only to yourself, but also to your numerous friends, and the artisans who work for you, that I should present the medal here to-day. I need hardly remind you that this medal is a memorial to my late lamented father, who did so much to encourage Arts, Manufactures, and Commerce, and who for eighteen years presided over the Society of Arts. The medal was instituted twenty-two years ago, and has been awarded to those who for distinguished merit in promoting Arts Manufactures, and Commerce, were thought well worthy of receiving it. From all you have done, Mr. Doulton, not only in this country but throughout all parts of the world, I do not think there is anyone more deserving of the high compliment we are now about to pay you. I need hardly tell you the great pleasure it affords me personally to hand you the Albert Gold Medal.

Mr. HENRY DOULTON, in reply, said—In receiving from your Royal Highness the Albert Medal, instituted by the Society of Arts in 1862, as a memorial of your illustrious father the late Prince Consort, and bearing his impress, I feel that you are conferring on me a very high honour. As President of the Society of Arts, as well as in other and manifold labours for the good of the people, the Prince Consort gave an impulse to the arts and manufactures of this country which has been growing and widening ever since, and the full measure of which we can even now hardly estimate. When I recall the roll of celebrated men, both Englishmen and foreigners, who in former years have received this distinction at your hands for "distinguished merit in promoting Arts, Manufactures, or Commerce," it is indeed most gratifying to me to learn that the award of the Council of the Society, composed of so many men eminent in science and art, was unanimous, and that it met with the approval of your Royal Highness. But you have deepened my obligation, and enhanced the value of the award immeasurably by graciously coming to Lambeth and conferring this honour upon me in the presence of my fellow-workers. For any services I may have rendered to art industry, I am indebted to the able and cordial co-operation of those who have been associated with me. No man ever had more loyal coadjutors, and it is most gratifying to me that they share with me in the honours of the day. The approval of your Royal Highness will be an incentive to future efforts. Whatever our shortcomings, we have at least striven to work in the spirit of our motto, "Le beau est la splendeur du vrai." I may perhaps be permitted to call to the recollection of your Royal Highness, that your first public act was to lay the foundation-stone of the Lambeth School of Art in this neighbourhood 25 years ago. In replying to the Rev. Robert Gregory, now Canon Gregory, on that occasion your Royal Highness expressed your hearty sympathy with the undertaking, and your earnest hope thas it would bring instruction in art within the reach of those who otherwise could not having obtained such advantage. That expectation has been abundantly fulfilled. The Lambeth School of Art, under the able guidance of my friend, Mr. Sparkes, has numbered amongst its students some who have become Royal Academicians. It has sent forth an army of workers, who as designers in pottery, metal, glass, and other art manufactures have had a most beneficial influence on the industries of England. In the higher education and in what are analogous to university honours, the Lambeth School has been most successful. The Royal Academy honours gained by Lambeth students from 1863 to 1865, which are traceable, include eight gold medals, forty-one silver medals, and eighteen other awards, as the Armitage prize, Landseer Scholarship, and premiums making a total of sixty-seven awards. In the same time 100 students have been admitted. As a proof of its continued vitality, I may mention that the awards of the Royal Academy to old Lambethians on the 10th of this month comprised Gold Medal, Travelling Scholarship, and £200 for best historical painting, the same for best sculpture, the Turner Gold Medal and £50 Creswick prize, the Landseer Scholarship, besides many other prizes—a goodly list of honours. It has given us at the Lambeth Pottery an unfailing supply of artists and workers, among whom I may name one of whom we are all proud, my good friend, George Tinworth, the exhibition of whose works two years ago, at Conduit-street, your Royal Highness and her Royal Highness the Princess of Wales were graciously pleased to open. His last work—one of four panels for the Bromley Davenport Memorial—is now on the wall before you. By the liberality of the City and Guilds Institute, a technical school has been established at Kennington, which is in a flourishing state and is doing excellent service in the more technical training of students. It is really an offshoot from the Lambeth School of Art. As illustrating the continuity of English history, may I, in conclusion, be permitted to remind your Royal Highness that the place in which we are now assembled is in the Prince's Ward—or as I prefer to call it by its old name, the Prince's Liberty of the Parish of Lambeth—forming part of the Manor of Kennington, of which your Royal Highness is the Lord. It might be called the cradle of the Princes of Wales. The arms of your Royal Highness, with its plume of feathers and its noble motto, was first assumed by one of the most illustrious and best beloved of his race—Edward, the Black Prince, who is specially associated with the manor. Tradition says that it was in Prince's Liberty that the Black Prince gave a grand and sumptuous banquet when he returned home fresh from the honours of Crecy and Poictiers. The conquests of your Royal Highness have been on other fields, but

> "Peace hath her victories
> No less renowned than war."

And in the paths of artistic and industrial progress, in international exhibitions, and in all humane enterprises for the welfare and happiness of her Majesty's subjects throughout her vast empire your Royal Highness has been a leader whom all good men have been proud to follow.

Mr. EDWARD BRYON, the senior foreman in the works, was next introduced, and presented the following address:—

"*To His Royal Highness the Prince of Wales, K.G., K.T., G.C.B., K.P., G.C.S.I. G.C.M.G., P.C.*

"We, the craftsmen, artists, and workers employed in the various branches of Messrs. Doulton and Co.'s Lambeth Potteries, desire to express to your Royal Highness our gratification at the honour you have bestowed upon us in thus visiting our manufactory.

"To the interest you have shown in the welfare of the working community, and the efforts made by yourself, by the Princess of Wales, and by your illustrious father, to extend the influence of our national manufactures, we attribute largely the high position which the Lambeth Pottery has now attained.

"We are anxious on this occasion to express a hope that we may in the future, by the excellence of our handicraft, by the sincerity of our efforts, and by our loyalty to the throne, continue to merit the high honour which your Royal Highness has this day conferred upon us and our respected employer.

"We are,

"Your Royal Highness's most humble servants, on behalf of the workmen employed,

"EDWARD BRYON. } In the Pottery Department.
HENRY BRYON. }
JAMES RANDALL BROWN. In the Pipe Works.
J. ENRIGHT. In the Sanitary Engineering Works.
W. H. MALTBY. In the Terra Cotta Department.
GEORGE TINWORTH. } In the Art Department."
FRANK A. BUTLER. }

When the address had been read,

The Prince of WALES handed the following reply to Mr. Bryon:—Gentlemen,—I thank you for your address, and for the kind expressions of loyalty and goodwill in which you allude to the Princess of Wales and myself. I can assure you that I am fully aware of the services that have been rendered by the firm of which Mr. Henry Doulton is the principal partner, to the cause of industrial art in this country. Let me congratulate you on having at your head one who is capable of perceiving that the success of a manufacturer chiefly depends on his securing the hearty co-operation of those who work under his direction; and I congratulate your employer on the success which he has achieved in obtaining the best and most efficient aid in carrying on the beautiful industry in which you are all engaged. I sincerely trust that the kindly relations now existing among you may never be disturbed.

His Royal Highness then left the show-room, and was conducted to another part of the building, where he was shown by Messrs Henry, J. D., and H. Lewis Doulton, specimens of art pottery, which were specially arranged for his inspection, and included a commemoration vase designed as a memento of his visit. The art studios were subsequently inspected by the visitors.

A leading article in the *Times* of the 22nd inst. contains the following remarks on the Lambeth Pottery:—

"Pottery is one of the oldest and most famous of English manufactures, and Lambeth has been for at least two centuries an important centre of the trade. It was about the same time, in the latter half of the 17th century, that in three or four different places English pottery took a start forward, partly under foreign and partly under native impulsion. The curious and interesting dishes marked 'Thomas Toft,' with their effective decoration, and their heavy lead glaze, date from this period, as do the still more remarkable works of John Dwight, such as the bust of Prince Rupert, now in the British Museum. At the same time was invented the 'salt-glaze,' now so universally used for one large class of pottery—the class that includes drain-pipes and ginger-beer bottles, as well as many finer articles. Just about this period, when the accession of William III. had brought England into closer relations with Holland and Germany, the brothers Elers, German potters, settled in Staffordshire, and to them must be attributed much of the improvement which henceforward began to be seen in Staffordshire ware. At Lambeth and Fulham the foreign workmen had established themselves earlier. They brought with them their old-established methods; and England soon began to produce for herself the 'greybeards,' or globular jugs adorned with a grotesque head, and the Fulham imitations of 'grès de Flandre' which are now so well known to collectors. Lambeth especially was the home of imitation. The Dutchmen worked there as they had worked at Delft, but they also copied, of course with less success, the works of Palissy, and even such Italian majolica as had found its way to England. Much of the rudely coloured and heavily glazed pottery which is still to be bought at country fairs is the direct descendant of what the Dutch potters made at Lambeth in the days of the Stuarts and of William III. The 18th century saw a great development of the industry, and many improvements, artistic and practical; but Lambeth kept itself to the homelier kind of objects, where there was, as it seemed, little scope for art. Chelsea and Worcester devoted themselves to the manufacture of porcelain, and Josiah Wedgwood made Staffordshire pottery famous throughout the world, but Lambeth remained plodding and undistinguished. Not till our own day did it emerge again; and its fame dates from the time when the Messrs. Doulton undertook the production, on a large scale, of what is commonly called 'Doulton ware.' We will not stop to discuss the question of the relation of this to other similar wares, such as the beautiful 'Martin ware,' which the curious may discover if they explore the recesses of Brownlow-street, Holborn; it is enough that Messrs. Doulton have brought the great public, in England, throughout the world, to see the beauty and utility of this particular class of productions. So strong and hard as to be almost imperishable; able at once to take sharp incised forms, deep colours, and a high glaze; this ware has proved itself fit for the most varied uses. Moreover, the fact that no two pieces are alike, but that each is designed specially and formed and decorated after the artists' fancy, is a guarantee that it will not sink into a mere trade manufacture."

The following remarks apply more particularly to the connection between the success of the manufacture and the establishment of technical education at the Lambeth School of Art:—

"It is impossible to dissociate such a ceremony as that of yesterday from the discussions that are now so frequent upon technical education and its effect both on artistic progress and commercial prosperity. The success of the Lambeth works, as Mr. Doulton yesterday fully admitted, is largely due to the efficiency of the Lambeth School of Art. Founded twenty-five years ago by the Prince of Wales, then at the very beginning of his public life, this school has flourished amazingly, and has produced on the one side a large number of artists, in the more generally accepted sense of the term, and on the other 'an unfailing supply of artists and workers' for the Lambeth Pottery. The two institutions have reacted upon one another. Students entering the school know that, if they show any talent for design, there is a remunerative opening for it close by; and the pottery finds an unfailing supply of young men and young women to draw upon for its designing-room. The example of this double organisation might well be more widely followed. The success of Messrs. Doulton's productions are a standing proof, to put the matter in the bluntest possible form, that artistic training pays."

Miscellaneous.

SOME LONDON CHANGES.

When an Act of Parliament is passed for any great London improvement, such as the formation of a new thoroughfare, the widening of a street, or the clearing of buildings for an open space, there are inserted clauses having reference to "compensation" by money payment, or exchange, for the owners of the land or of buildings affected by such improvement. Viewed simply commercially, this may seem not only to meet all the requirements of the case, but to be a full recognition of all that the improvement involves, and for those immediately concerned, no doubt it generally does, indeed not unfrequently the people so compensated are gainers. But an improvement of any magnitude is attended with ramifications of influences far beyond those originally immediately concerned. The value of property all around is affected. The neighbouring bye-streets gradually change their character as to their inhabitants, and frequently they are rebuilt. The additional overcrowding also caused in London by extensive alterations is a subject that was formally brought under the notice of the Royal Commission "On the Housing of the Working Classes." Among apparently minor matters new lines of omnibuses are originated. Not unfrequently sewers have to be altered, while the gas mains almost of necessity are, as well as the water supply. Post-offices, police-stations, fire brigade stations, cab ranks, are involved in the change. When local industries and shops are included in the changes brought about by any great improvement, it becomes very difficult to trace all their ramifications.

Not the least important among them is the sweeping away of dwellings which help to throw light on the social habits of the people of a district. This sweeping away is immediate in the direct line of a new street, and it soon extends all around. Whole districts in London have been modified, buildings have been cleared away without any of those records which would be so valuable to future historians, who will be better able to take a wider and calmer view of the relative value of the various elements of our progress or degeneracy than those living among such rapid subversions and innovations.

Westminster affords, at the present time, a good illustration of the effects of two very important changes, the cutting of Victoria-street, and the construction of the underground railway. Though the route now called Victoria-street was commenced in 1845, and formally opened in 1851, the changes which the cutting of the street have already brought about are by no means all that are likely to follow; they are still in progress, and an interesting point to notice is this. A large part of old Westminster consisted, and what still remains consists, of buildings one storey high; the new buildings run up seven or eight storeys. In many places at present, old one-storeyed creeper-covered buildings can be seen in juxtaposition to the new palatial structures which tower above church roofs. The erection of these gigantic structures has suddenly changed the character of the district, without any of the intervening old-fashioned growth from the simplicity of a cottage district gradually developing onwards to magnificence. Land has hence suddenly increased manifold in value, and, in consequence, that rows of rustic cottages with their garden ground should continue to occupy space on which mansions might stand is not to be expected. Thus the influence of the cutting of the thoroughfare does not end with just the actual making of it. The thoroughfare was needed as a thoroughfare. The Act of Parliament was passed authorising the formation of the thoroughfare, and other results have sprung from it.*

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* Lord Shaftesbury, in his evidence before the Royal Commission on the Housing of the Working Classes, stated that the Westminster improvements of 1866 led to excessive overcrowding.—Question 14.

Nearly opposite the public house, the "Royal Standard" there was a wall which cut off Westminster from the old "Eburie estate."* All about this blocked up end an overcrowded population had accumulated. A stream which, like all London streams, had become an open sewer, ran down, and at the present time, still as a covered sewer, runs down between the back of what is now the eastern side of Vauxhall-bridge-road and the roadway named Carlisle-street, though not yet a street. It would seem that this stream—a "scientific frontier," as has become the fashion to call natural boundaries—had the practical effect of sharply separating off the Westminster dwellings from the Ebury estate. The principal thoroughfares of Westminster were Rochester-row, and the route from the Abbey by way of Tothill-street, York-street, and James-street, to Buckingham-gate. Between these two there does not appear from the maps to have been any other thoroughfare, and portions of Westminster were, by thus being shut in, practically as isolated as if they had been in some other part of the country.

Increase of population, the gradual encroachment on garden ground, and the living together of many in dwellings originally simple country cottages, brought about inevitable effects on the social condition of the people. The state of affairs that had to be faced at the commencement of the present reign have been made popularly known by the Earl of Beaconsfield, at page 132 of the third volume of "Endymion," while Blue-books tell a fearful story.

Probably few know anything of Westminster courts, except from what they have read. But a reference to the parts of Westminster that have been, and are being, swept away, would be incomplete without stating what can be gathered from a present actual examination of the district. How came the squalid courts, those courts which have so often been pointed at as blots in a wealthy metropolis? To one accustomed to take things as he finds them, as if placed by design, they are inexplicable. But to an antiquary accustomed to trace great changes by small degrees they are perfectly simple.

If anyone will take the trouble to walk down Ship-court, and look in at the adjoining Garden-court, both at the south end of the grounds of the Grey Coat Hospital, or will enter Hendon-court, near the continental entrance of Victoria-station, or take any of the courts off Francis-street, on the south side of the site of the recently removed Tothill House of Correction, he will find that the following description holds good, with minor differences, for all of them as regards their external appearance.

The cottages are of one storey, with no rooms below ground. The walls are of red brick, in a few exceptional cases plastered and whitewashed, and the roofs are all of red tiles. Those window frames that are of thick solid wood still remain as they were originally, but some have given place to the more slender modern type. The number of lattice-work door porches to be seen would seem to indicate that they were "the fashion" when the cottages were built. These rows of cottages all run off from the main thoroughfare. Just as isolated cottages in the country generally have their gable end to the road, so these are built in rows, often at right angles to the road, but always in some way not parallel to it. The most remarkable feature, however, is that those which retain their early condition have gardens, and their walls are covered with creepers. In many cases these in summer are so thick not a brick is to be seen, while the porches are festooned with green, and the windows are shaded by the trailing branchlets. The creepers are vine, jessamine, sweet pea, hop, virginia creeper, rarely ivy, and in a few cases fig. The gardens, with here and there an exception, where what is now called "carpet bedding" with variegated foliage has been adopted, grow the old-fashioned larkspur, marigold, mignonette, London pride, common geranium, dahlias, evening primrose, sunflowers, hollyhocks, camomile, old man's beard, gooseberry and currant bushes. In many cases the paths are of the old-fashioned cobble stones, very few are gravelled, while for fencing wood is more generally seen than iron.

Such are some of the more readily noticed features of these courts, and it will be seen from this cold and colourless description what there is to delight an artist's eye. When, further, it is mentioned that in these courts children play together without fear of passing traffic or policemen, and that the housekeeping mothers are sometimes seen varying their every day work by a chat from garden to garden, it requires but little imagination to think of these courts as in some village remote from a railway station—and yet they are in Westminster in 1885.

But how come the squalid courts? The process of degeneration can be traced step by step in other courts in the district.

The exact localities of the courts where gardens still are to be found, and where the loving care for plants is still to be seen, have been mentioned. It may not be agreeable to the occupiers of those which are sinking or which have sunk to a lower stage to have the locality mentioned; but they are within the district referred to, and whether the inferences drawn from appearances are correct or not, can be easily judged by a personal visit. The first step seems to be to use the garden for some business purpose, such as the erection of a shed for work, or the breaking down of the garden fence to find room for a truck. There is one court at present with only one garden ground intact, all the rest being altered to suit the needs of the cottage occupiers. Want, necessity, remunerative utilisation of space, seems to be the first motive. Then, the love for the garden and its pleasure once gone, and the pride in its trimness lost, carelessness about accumulation of rubbish follow

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* A plan of this is given in the appendix to Mr. Loftie's book on London.

There are courts which show not only this stage, but the next, where the creepers are gone, and the landlord, removing all paling and rubbish, has whitewashed the outside walls, and paved the court. Such a step is perhaps, from a sanitary point of view, to be approved. Rubbish has accumulated. To clear it, pave the court, and insist that no rubbish shall be allowed, is, without doubt, one way to remove the evil. But the children have no longer flowers around them in their play. A paved court for tops, or marbles, or for chalking out lines for hop-scotch is useful. But there still are some who believe in a moral influence in flowers. Another way of meeting the difficulty might, perhaps, be for the landlords to require that garden ground should be kept as such. From the paved court, clean and tidy, to the foul places marked out for demolition, the stages are easily understood. The whole series can be seen in Westminster, and the sight of them affords subject for reflection, which, here, it would be out of place to dwell on. Sanitation is a many-sided question. But it should be recorded that here, in Westminster, are to be seen courts as thoroughly country in aspect, and possibly, by their connection with the main drainage, as healthy as could be met with in our most favoured shires, and as pleasant, always excepting that the view is limited. In the history of London changes, these courts must not be forgotten. What social changes, what changes in habit these structural changes imply requires the knowledge of those who visit the occupiers on errands of mercy, or are brought personally in contact by having business with them. Such a district is worth the study of those who set themselves the duty of writing on "the housing of the poor," or of those who believe that surroundings have influence on a healthy condition, taking the word "healthy" in its wide sense, and "surroundings" as something more than those pipe and trap and grating arrangements which by law fall under the supervision of those whose office it is to detect where there is anything which is "a nuisance or injurious to health."

One stage illustrative of the way in which open garden ground gets changed to a bricked-in court is to be seen near St. Stephen's Church. A few months ago the gardens in front of a row of cottages had a low wooden fence about a yard high. This has been all along replaced by planks about seven feet high, some of which have been tarred. Already the interior arrangements of the gardens have been changed, little sheds for various purposes being erected. From this wooden fence to a brick wall the change will be only be one of material, not of arrangement.

The effect of cutting the Metropolitan Railway has been somewhat different. For the most part, where it has had any effect at all, it has caused only gaps; but in many places, rnnning underground, it has led to no alteration. It has had a very remarkable effect on that large group of old houses and courts lying between York-street (on the north), Little Chapel-street (on the south), Great Chapel-street (on the east), and the junction of James-street and Castle-street on the west. In the Rocque map of 1746 these thoroughfares seem to have surrounded a group of buildings about 150 yards west to east, without any carriage way running through them, but with about a dozen courts, some of them ending in a *cul de sac*,* some being thoroughfares for foot passengers. It is not quite clear from the maps, in one or two cases, whether these were thoroughfares or not. But leaving the doubtful cases out of consideration, as a question for those antiquaries who may think it worth their attention, it will be seen that [beginning at the western end] these thoroughfares remain. Horseshoe-court, Smith's-place, Smith's-rents, and Palmer-street (or Gardeners'-lane as it is called). Then Blue Anchor-court, which used, apparently, to be an extensive one, is swept away to make room for the St. James's-Park-station. The entrance, and a few yards of it remain, and the name is preserved. Then, turning round to what is now called Great Chapel-street, but formerly Broad-place (not to be confounded with the Broadway, which always has been the name of the wide part of that thoroughfare named Tothill-street, and continuing as York-street, formerly called Petty France), there is a short court, which, from the maps, appears always was a short one, and then St. Ermin's-hill. This used to be a thoroughfare, probably always wide enough for vehicles, as the existing relic is, passing through to where the new Town-hall now stands. The making of the station has swept away a large part of this, so that the road now leads nowhere. It is only by referring to old maps that the meaning of the present short St. Ermin's-court becomes apparent.

In giving names to lines or groups of houses, there does not seem to have been any consistent distinction observed between court and street. A court strictly, as the origin of the word shows, is an enclosed place. St. Ermin's† was a street rather than a court, and was too narrow for garden ground. Eliza-court and its surroundings are all swept away. The railway has cut the whole group (as defined above) in two. Smith's rents,‡ with its many small side courts, remains as an illustration of how houses came to be built in proximity to one another. It is difficult to believe that such a pattern [if the word may be used] for a "court" was designed. It is more probable certain houses were built facing different ways, that their garden ground was from time to time built on, and hence the curious "pattern" which these buildings present on a map. The actual structure of some of the present houses is, no doubt, much newer than the lines for which they are built. For a complete row of houses which modern alterations have not swept away, there does not appear to be any better illustration than Pye-street, and as their repair from time to time is not neglected, they may perhaps stand for some time to come. They form an interesting contrast to the high block of model lodging-houses facing them.

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* On the believed moral influence of a *cul de sac*, see Lord Shaftesbury's evidence before the Royal Commission "On the Housing of the Working Classes." Question 58.

† Why St. Ermin at all is not clear.

‡ The word "Rents" is of common occurrence in Westminster.

That the love of flower growing has not died out with the destruction of gardens is evidenced by the extent to which what has come to be called "window gardening" is favoured in Westminster.

There are two relics of public buildings of old Westminster, in Emmanuel or Dacre Hospital (founded by Lady Dacre) and the Grey Coat Hospital, still standing, and apparently likely to remain. There were formerly others of a similar kind, but they have been pulled down. The last remnants of Palmer's village, which had its green at the commencement of the present century, and where it is said the May-pole dance was then a custom, have within the last few months been swept away for the erection of the head-quarters of the London Scottish volunteers. At the present rate of improvements, it seems probable that very soon not a vestige of old Westminster will remain.

Another illustration of the indirect changes brought about by the improvement of thoroughfares is to be found in what is called the "new street," from Piccadilly-circus to near the British Museum. It is not strictly a "new street," as for the greater part of its length the "improvement" consists of widening the existing streets, Dudley-street, King-street, and Richmond-street. The whole of the eastern sides of these streets were removed during June, and the only absolutely new cuts needed have been at the north end, the short piece from Bloomsbury-street into Oxford-street (opposite Mudie's), and at the south end a cut through the block of buildings between Rupert-street and Great Windmill-street, and a shorter one from Great Windmill-street to Tichborne-street. These two cuts have been gradually effected during the last few months. The widening of the road at Piccadilly-circus has been the most remarkable of the clearances made.

The triangular block of buildings surrounded by Tichborne-street, Piccadilly, and the Circus, was pulled down between July 29th and August 20th. The work was commenced on July 29th, by putting up hoarding all round, with projecting boards, sloping upwards, to guard against falling *débris*, and was concluded during the night of the 19th and early morning of the 20th of August. It can be safely said that no London alteration has been completed under such unusual effects of light. Laths and slight woodwork were used for bonfires, to enable the men to see during their somewhat dangerous work, and there was a sufficient breeze to cause that flickering of the red light so often described as weird. From the new Pavilion opposite shot out the cold blue of the electric lights, obscured every now and then by the passing workmen, while the yellow light of the gas lamps occasionally preponderated. When the streets which enclosed the blocks of buildings were first formed, not even gas was dreamed of, for they appear in Overton's map of 1666. They then had different names, and the actual houses have, no doubt, been rebuilt more than once. The name, Piccadilly (on the south side of the block), occurs on all the maps. But Titchbourne-street is in Horwood's map of 1782, called Shug-lane, while in Rocque's maps it is, like the continuation, now Glasshouse-street, called Marybone-street. In the third edition of Horwood, 1813, the name Tichbourne-street appears. When the circus was formed, the south-west corner of the block (which included the old "Black Bear" Inn) was cut away, but with this exception, the shape of the block now removed has been the same from some time prior to 1666. The earlier history is not traced with certainty, but the adjacent Windmill-street (or lane as it probably was called first) indicates that names were given to thoroughfares in this part of London, soon after the time of Aggas's map, though none are given there.

With the exception of the erection of the Pavilion which, with the aid of electric light, was carried on night and day, and which could be seen to grow from hour to hour as the stones were brought already shaped, no rebuilding in the direct line of the street has been commenced. But during the spring and summer great changes were made in Rupert-street, Upper Rupert-street, and Little Pulteney-street. Where the market, with its narrow ways and crowded stalls, used to be held, even up to a few months ago, are now lofty shops with polished granite columns, while above them rise high buildings with stone largely introduced in their architectural features. The whole neighbourhood is undergoing a remarkable transition, and the contrast between the dirty and neglected low buildings and the new is very striking. Dates under the names of streets, on the stone blocks, are not always the dates of the first making of a street, but the following should be mentioned:—"Crowne-cowrt in Poltney-street, 1708." (This is now gone). "Archer-street, 1764," and then further north in Wardour-street at the junction with Edward-street are two, "Edward-street, 1686," and "Wardour-street, 1686."

An important feature in the "new" street will be a circus, where King-street and Dudley-street meet, and where Moor-street, Crowne-street (which has a stone 1775), Little Earl-street, West-street, and the new street through the model houses, Sandringham-buildings, all converge. [This street through Sandringham-buildings is part of the new road from Castle-street, on the east of Leicester-square, to Tottenham-court-road.] The scene is at present a curious one. Little Earl-street runs into the Seven Dials, and is still on certain evenings one of the noisiest and most thronged of "curbstone markets." Many shops in the neighbourhood are closed in prospect of their demolition; while the vast open space north of Sandringham-buildings looks as if the district had suffered from a bombardment.

SOURCES OF SALTPETRE.

By C. G. Warnford Lock.

Whilst every miner is attracted by mineral veins which promise to yield metals, the majority overlook a class of earthy products which, nevertheless, possess considerable commercial value. Foremost amongst these is saltpetre, or potassium nitrate. The following notes on this useful salt have been collected by the writer at various times, and in various localities, and will probably be interesting to many readers of the *Journal*, as accessible information on the subject is not abundant, and some of the deposits alluded to seem worthy of better development.

The generally accepted conditions necessary for the formation of saltpetre are (1) the presence of decaying organic matter, whose decomposition affords a supply of nitrogen; (2) access of atmospheric air to oxidise the nitrogen into nitric acid; (3) sufficient potash in an available form (such as wood ashes or decomposed felspathic rocks) for the nitric acid to combine with as fast as it is liberated. Given these conditions, the formation of the salt will take place in very varied situations, being most commonly observed in countries where a tropical climate favours the decomposition of organic matters. With this introduction, we may proceed to indicate the chief localities of production.

France.—Though commercially insignificant, it is worth noting that a considerable accumulation of saltpetre takes place in a series of caves near Roche-Guyon, and Mousseau, on the banks of the Seine, which are utilised as stables; the nitrous earth yields on analysis from 3 to 5½ per cent. potassium nitrate.

Spain.—The soil in some parts of Arragon, Catalonia, and New Castile, bears a nitrous efflorescence, which is worked at Alcazar de San Juan, Zaragosa, and Tremblaque.

Italy.—Saltpetre caves occur at Pulo di Mofetta, on the Adriatic.

Hungary.—Great numbers of nitre pits are met with around Semeny, Debreczin, and Nagy Kallo (Kanizsa).

Cape Verde Islands.—Much has been said about the existence of saltpetre in the Sotavento or "Leeward" portion of this archipelago, and it has been reported of the two Rombos, Brava and Fogo, that their deposits were the subject of rational working. The chief supply, in Brava, was reported at the Porto do Anciao, a little bay on the south-west. The veins here were said to occupy several horizons, and to vary in thickness from a knife-edge to two inches. From these veins the natives dislodged the mineral by means of bricklayers' hammers and small axes. Recent inquiries tend to throw discredit on these circumstantial statements, which may have been founded only on the evidence of the Portuguese traveller Valdez, who described the islands without troubling to pay them a visit. Now it appears that Fogo alone affords a small quantity of saltpetre, gathered in a precarious manner by the residents.

Turkey.—In Macedonia, saltpetre is collected in the neighbourhood of Uskiub and Kiuprili, in the Vardar valley, and transported thence to Constantinople.

Asia Minor contains very extensive saltpetre deposits, which have not received the attention they deserve. These may be said to lie between 30° and 36° E. longitude from Greenwich, and between 37° and 39° N. latitude. In this region there is a vast expanse of saline marsh, whence culinary salt and saltpetre are got by the people of the district. In the neighbouring hills of red sandstone, salt is dug out of horizontal beds. The Lake Buldur presents the curious phenomenon of affording quite fresh water at the surface, while beneath it is distinctly nitrous. At the village of Karabounar, the entire soil is strongly impregnated with saltpetre, and it even forms an efflorescence on the surface, after rain has fallen. Obviously volcanic action has played an important part in the formation of these deposits, just as it has done in the sodium nitrate beds of Peru; for everywhere the soil is more productive of the mineral as the volcanic strata are approached. The soil is removed and washed with hot water; the solution is then evaporated in wooden troughs. The industry at this spot is, or was, a Government monopoly; the whole yield, some 20,000 to 25,000 okes (say 20 to 25 tons) being sent to the powder factory at Constantinople. The price there paid for it is 56 paras per oke (say £14 10s. 2d. per ton), of which sum 16 paras (£4 2s. 10d.) per ton are allowed for carriage, and 40 paras (£10 7s. 4d.) per ton for cost of preparation.

At Ak Serai the marshy plain is covered with a yellow efflorescence, mainly consisting of saltpetre which is collected in large quantities. In fact, saltpetre forms, with madder, the chief commercial staples of the district, and the decline of the madder culture brought about by the development of the coal-tar dye industry, leaves the saline product the principal source of profit to the inhabitants. The degree to which the soil is impregnated in this neighbourhood is evidenced by the fact that, after rain has fallen, effloresced saltpetre is scraped in large amounts from the very walls of the houses. But being here likewise a Government monopoly, the residents are not permitted to gather it from their dwellings on their own account, but are paid a small sum for their trouble by the contractor who farms the monopoly. At a distance of about five miles from Ak Serai, in a N.N.W. direction, the soft muddy ground is permeated with saline matters, which feature extends far to the S. and S.E., the river Bens Su losing itself in the soil before reaching the great salt lake of Touz Ghieul.

The plain lying to the N.E. of Injesu and Mount

Argœus (Erjish Dagh) is, in some places, covered with a thin saline incrustation, which would probably yield more or less saltpetre by lixiviation. Near the western gate of the town of Cæsarea again there are some extensive saltpetre works, where the mineral is gathered in large quantities from the soil. Kiz Hissar also contains numerous saltpetre works; the article is collected in abundance from the soil in and around the place, as much as 40,000 okes (say 40 tons) being sometimes prepared in one season. Mention may here be made of Lake Asmabœus, lying in the midst of a perfectly level plain; it measures about 40 ft. in diameter, and is full of brackish turbid water, bubbling and "boiling" all over the surface, but especially in the centre, the commotion being evidently caused by an escape of vapour, and suggesting the propriety of testing for the presence of boracic acid, which occurs in a parallel manner in the Tuscan lagoons.

The extensive plain of Bor, or Nigdeh, which is flooded in winter, is, in dry weather, covered with a saline efflorescence in patches, the character of which is testified by the presence of some remains of dilapidated nitre works. In many of the localities above alluded to, there are also indications of boracite and pandermite, awaiting further research.

India.—Some saltpetre is obtained from the slimy mud deposited by the River Ganges during the flood season. Analysis of a nitrous earth from Tirhût, in Bengal, gave 8·3 per cent. of potassium nitrate, and 3·7 of calcium nitrate, or 12 per cent. of total nitrates. The soil around old buildings in the Punjaub is very productive of nitre, which appears as an efflorescence, not to be confounded with the sodium sulphate crust occurring on the *reh*, or barren lands. The deposit is scraped up as often as it is renewed, and submitted to simple treatment for the separation of the nitre from the accompanying dirt by the agency of water and filtration. A small spade is used in collecting the earth, which is taken off to a depth of one to two inches, and piled in heaps two to four feet high, where it is left without taking harm till an opportunity arises for transporting it to a spot where water and fuel are available. In the upper part of the Punjaub, the extraction process is conducted in a series of wide-mouthed earthen pots, with an aperture in the base, supported on earthenware stands, so as to admit of placing cups beneath the pots. On the bottom of each pot is spread a bed of straw, covered with a layer of wood ashes; above this, the nitrous earth is added till it reaches nearly to the top of the pot. Then water is applied till all soluble salts contained in the earth have been dissolved and carried in solution into the cups below. The straw bed acts mechanically as a filter to hold back insoluble matters; the wood ashes act chemically, affording potash in an available form, so that any calcium nitrate present may be converted into potassium nitrate, the nitric acid in the calcium nitrate exchanging bases with the carbonic acid united to the potash in the wood ashes. The very weak nitrous solution thus obtained is used instead of fresh water for washing through the contents of another series of pots, and thus becomes gradually charged with saltpetre to the extent of 2 or 3 per cent. The next process is the removal of the water and crystallisation of the salt. This is conducted in elliptical iron dishes, measuring one or two feet across and six to nine inches deep, heated from beneath; as evaporation proceeds, fresh liquor is added, during a period of twelve to eighteen hours. The scum which rises is skimmed off, and at a certain point of concentration the crude potassium nitrate, with accompanying saline impurities, is abundantly precipitated. This product in some districts is termed *dhouah*, and contains 45 to 70 per cent. of potassium nitrate. The small pans used in the Upper Punjaub give 8 to 16 lbs. of crude nitre per shift of thirty to thirty-six hours. Over 4,000 pans are kept working in the Punjaub, paying an annual tax of two rupees. In addition, there are over a dozen large shallow basins, called *agar*, where sun-heat is utilised for evaporation; these pay eight rupees yearly.

In the different districts, slight modifications of the process described above are in vogue. Thus, in Mooltan, the liquor, after twenty to twenty-four hours boiling, is often run into a vat to cool for a night, and next morning the crystals are raked out and washed in a woollen cloth, being then tied up in it, and exposed to the sun till the moisture has been dissipated. Sometimes the filter is made on the ground in an inclined situation, being formed with mud walls lined with stiff clay on three sides, the remaining side being left open for escape of the liquid, but provided with reeds or closely-woven grass mats, with or without a bamboo false bottom; the liquid passes into a reservoir made of pucka masonry. In Guzerat, the nitrous solution is passed through a cloth filter; it is evaporated to about one-fourth its bulk, and on cooling affords an impure crystalline product (*dhouah*) worth abont three rupees per maund (say, 8s. per cwt.). When re-dissolved, filtered, and re-crystallised, forming *kalmee*, it is worth eight rupees per maund. The following table of the average cost per ton of Indian saltpetre is instructive:—

	£	s.	d.
Prime cost of crude material at the factory	4	2	0
Salaries, bags, packing, &c.	1	14	2
Freights and expenses from factory to Bombay........................	5	17	3
Interest on outlay at 9 per cent.	0	13	8
Government licence.....................	0	2	7
Insurance at 7 per cent.	0	17	1
	13	6	9
Profit per ton	1	0	3
Selling price at a brisk demand at Bombay	£14	7	0

Indian exports of saltpetre reach something like 25,000 tons annually, with a value of over half a million sterling.

Ceylon.—The nitrates of potash and lime are of frequent occurrence in Ceylon. Some thirty places might be enumerated where saltpetre is produced and has been prepared for market. The formation of the mineral is apparently confined to caves in dolomitic rocks, the felspar in which contributes the potash base. The caves are generally remote from inhabited places, being situated in desolate and not easily accessible regions. Future explorations in the interior will probably add to the number already known. While some of the caves are the resort of vast numbers of bats, whose dung accumulates in them, others are quite untenanted.

An analysis of the most productive nitre rock near Doombera, in an unfrequented cave, showed 2·4 per cent. potassium nitrate, and 0·7 per cent. of magnesium nitrate. The nitre earth from the great cave in Lower Ouva, near Wellaway, yields 3·5 per cent. of calcium nitrate, and 3·3 of potassium nitrate. The nitre crop is harvested during six months of the year by chipping off the incrusted portions of the walls of the caverns; the fragments are reduced to powder, mixed with an equal portion of wood ashes, and dosed with water. The potassium nitrate present, as well as that produced from other nitrates by the action of the wood ashes, is dissolved by the water, and the solution is evaporated first in pits exposed to the sun's rays, and then to the crystallising point in fire-heated pans.

Burma.—Some of the caves contain accumulations of nitrous earth, and the preparation of the salt is carried on extensively between Pugan and Ava, on the Irawadi.

Thibet.—In the government of Rudokh, saltpetre is obtained by digging up the soil, which is put into brass vessels, and treated with hot water. The solution thus formed is decanted into another vessel, and there allowed to cool, that the nitre may crystallise out. By the crude native method, one man can prepare a sheep load (say 20 lbs.) in three weeks.

Turkestan.—Within the limits of the Khanate of Chiwa, on the left bank of the Amu-Daria, in a south-westerly direction from Fort Nukus, lies a district some two miles square in area, covered with a layer of nitrous earth, exhibiting the following composition:—

Matters soluble in water	27·89
,, insoluble in water	72·11
The soluble portion consists of:—	
Potassium nitrate	5·52 per cent.
Sodium nitrate	4·05 ,,
Magnesium nitrate	1·04 ,,
(Total nitrates)	(10·61) ,,
Sodium chloride	12·90 ,,
Calcium sulphate	3·25 ,,
Magnesium sulphate	0·66 ,,

Saltpetre abounds in Eastern Turkestan, especially in the hills beyond Karshi (Moore's Neksheb), a large town 91 miles south-east of Bokhara. Here, previous to 1875, the Emir had a large powder factory, the powder of which was sold in Bokhara for 15 kopecks (5d.) per 1¼ lbs. Other factories existed in Khokan. According to some authorities, however, the best saltpetre is procured from Guzar, in northern Afghanistan, which is said to rival the Persian volcano Demavend itself in this respect.

Sumatra.—The nitre caves in the county of Caltown, near the land of the Duni river, are filled with nests of innumerable birds of the swallow kind, which abound the more the further the caves are penetrated. It is their dung, forming a deposit in many places 4 to 15 feet thick, which forms the saltpetre. A cubic foot of this earth, on boiling, will afford something like 8 lbs. of nitre.

Brazil.—In the Rio das Velhas, on the right bank of Ypoeira, saltpetre is found in quantities at the south-eastern side of the Serrote, in a series of caves. The process of extracting the nitre from the chocolate-coloured earth is one of lixiviation. The earth is put into a bangue or strainer, generally consisting of a square pyramid of boarding, with the base upwards. The poorer people use a hide, supported on four uprights. When exhausted with hot water, the nitrous particles find their way, duly filtered, through a tube leading to a *coche*, or trough, often a bit of old canoe. The *decoada*, as it is now called, is a thin greenish liquid, which must be boiled in a *tacho*, or metal pan, like that used for sugar. This *tacho* is sometimes mounted upon an ant-hill. The nitre is purified by repeating the process, and assumes a yellowish-white colour. It has been used for making contraband gunpowder.

AGRICULTURE IN JAPAN.

Field farming in Japan is unknown, the tillage being really gardening, but of the most thorough character. Consul-General Van Buren says that fully one-half of the population are farmers, and of the day labourer or coolie class a large number are employed in the cultivation of the soil. The average size of the garden farms is about half an acre. The fee simple of the soil, formerly in the feudal lord, is now held by the farmer. The area under cultivation has been extended fully one-fifth within the past ten years. The Japanese Archipelago extends north and south through fifteen degrees of latitude, and the cultivated areas are at all altitudes, from the sea level to 10,000 feet above, with the climate of the temperate or sub-tropical zones. Of the 50,000,000 acres of tillable land, a little less than one-fourth, or about 12,000,000 acres, are under cultivation. This is owing to the absence of good roads and proper means of transportation; most of the carrying in the farming districts is done upon the backs of men and animals. Rice is the staple product of the country, growing in all districts of the empire; about 6,800,000 acres, or more than half of all the area under tillage, is, during the summer, devoted to its cultivation. Wheat is grown in all parts of the empire, and it is estimated that the yield averages twenty bushels to the acre. It is mostly eaten in the form of cakes, cooked without any process of fermentation. The wheat flour is ground in a small stone mill, and is bolted by hand in a small box about two feet wide and three feet long. The uplands are preferred for wheat growing, and the soil is thoroughly dug up and pulverised with a long-bladed mattock. It is then divided into small plots, each of which is then furrowed by the same instrument into rows, three or four inches deep and twelve or fifteen inches apart. Into these furrows ashes and a thoroughly decomposed compost is scattered, and in October seed is dropped by hand, about one to one bushel and a quarter to the acre, and covered by the mattock to the depth of about one inch and a half. The ground is turned up two or three times a month, and liquid manure is applied three or four times during the winter and spring to the roots. In the autumn some hardy vegetables are planted between the rows of wheat. The wheat ripens in May, and is cut by a knife and bound into small bundles, which are either hung up on trees or bamboo poles, or laid on hard ground to dry, when it is carried to the farmhouse, where it is thrashed. The threshing process consists of first pulling off all the kernels of grain and the husks by means of a row of iron teeth, long and saw-like, closely set in a stick of wood. Between these teeth a few heads of wheat are rapidly drawn, tearing off the kernels and their coverings. The grain is separated by threshing on mats with a flail, and the chaff is separated by one person slowly pouring the grain from a scoop-shaped basket held four or five feet from the ground, while another person stirs the air with a large fan. The wheat is then put into straw sacks and carried either on hand-carts or on the backs of horses to market. Barley is a much more important product than wheat, and is more universally eaten; and it is also used for making *saki*, a liquor largely consumed in Japan. That which is made into flour is ground and bolted in the same manner as wheat, and is also cooked without fermentation. The mode of cultivation, harvesting, and threshing are the same as with wheat. The sugar of Japan is made from that species of the sorghum plant known as the Chinese sorghum. It grows luxuriantly in the southern parts of the empire. For three or four hundred years the processes of granulating and refining sugars have been known and practised. Sorghum is grown from cuttings and not from seed. In September selected stalks are cut and buried in trenches a foot deep. Through the winter, from each joint of the stalks sprouts shoot out, and in the spring these joints are cut off and set out in rows fifteen or eighteen inches apart, and about the same distance from each other in the rows. The ground has previously been dug up and pulverised by a long-bladed mattock. The fertilisers used are ashes, fish, decomposed hay, straw, and seaweed, and the plants are thoroughly hoed and irrigated. In October and November the leaves are stripped off, and the stalks are then cut, and the hard outer covering removed; the remaining portion is then ground between rollers of stone on hard wood. The cane juice is then boiled in iron kettles till the granulation takes place, when it is placed in bags and pressed dry, the expressed syrup being used as molasses. Dry, upland soils are required for the successful growth of the cane, and the expenditure in labour and fertilisers is greater than for any other crop. Tobacco is also an important product, about 90,000,000 pounds being produced in one year, and amounting in value to £1,500,000. It is grown on uplands, and the seed is planted at the end of March, or beginning of April, in rows about 15 inches apart. In September the lower leaves are picked, at the beginning of October the middle ones, and the upper ones at the end of October. The leaves so picked are dried and packed in small bales. Beans, peas, and other leguminous plants are extensively cultivated in Japan, and Consul van Buren says that there is probably no country in the world where this class of food-plants enters so largely in the diet of a people as in Japan. The cultivation of tea is one of the most important branches of Japanese agriculture, the total production for the year 1880 amounting to as much as 90,000,000 pounds. As regards textile fabrics, silk is the most important, the mulberry tree growing on nearly all parts of the islands south of Yesso. The principal provinces in which it is cultivated are Iwate, Miyagi, Yamagata, Fukushima, Gunba, Tochigi, Chiba, Iberaki, Kanagawa, Nagano, Yamanashi, Shidyuoka, Gifu, Ishikawa, Shiga, and Kioto Fu. The variety of the mulberry most in use is the *Morus nigra*, and it grows from five to ten feet in height. Hemp is grown on the lower and richer soils, in drills sixteen inches apart. It is sown in March or April, and receives the same careful garden tillage as all other products of the soil in Japan. The soil is carefully prepared by the small Chinese plough, or the long-bladed mattock, and well manured in the drills where the seed is sown. During the summer it is frequently hoed, and fertilisers are applied to the root of the plants. All hemp lands are flooded three or four times in the season, from the irrigating ditches. The stalk, usually ready for harvest in August, grows from four to seven feet high, and is pulled and spread on the ground, where it is allowed to rot, and the fibre is easily separated. This is done by beating with a bamboo stick. The resinous substance is removed by hand-scraping, with a sharp-edged bamboo knife, and the fibre is of great length, strength, and lustre. Flax is not grown in the country. Consul van Buren says he cannot render too warm a tribute to the thoroughness of the present tillage by the Japanese farmers, the value of which is proved by its immense results. When the mattock or broad-edged pick is alone used, the whole surface of the ground is dug up and turned over to the depth of eight to ten inches, and then the whole of the soil is pulverised and raked over, until not a lump of earth is left. When the small Chinese plough is used, the soil is ploughed and re-ploughed from four to eight times.

THE FISHERIES OF ICELAND.

Consul Paterson, in his last report on the trade and industries of Iceland, says that the principal fishing season is from February to May, and at this time large numbers of landsmen come down to the coast to join in the fishing. Open boats, each manned by six to twelve men, are used for the most part, though there are smaller craft, manned by two or four men, which as a rule fish near the land. The fishing is carried on chiefly by hand lines, though long lines and nets are also used in some places, and under certain restrictions, as their general use is said to be injurious to the fishing. Each day's catch is divided into equal shares, one to each man, and one or two to the owner of the boat, according to its size. On landing, the fish are at once gutted and laid in salt, and after some time they are washed in sea water to remove the excess of salt, piled in heaps to drain, and then alternately dried in the sun and dried in heaps, covered by boards weighted with heavy stones until completely cured. There are no professional curers; each fisherman cures his own catch, and sells it to the merchants when cured. Salt fish intended for export to Spain must be of a certain size and quality, and is therefore examined before shipment by skilled men appointed to this duty by the authorities, who reject all that does not come up to the standard. The rejected fish, along with small cod and haddocks, go for the most part to England, Denmark, and Germany. The cod heads and sounds, or swimming bladders, are carefully dried, the former being used as food in the country, and the latter exported and made into gelatine and isinglass. The roes are salted and exported to France and the Mediterranean, where they are used as bait in the sardine fishery. The livers are collected and the oil is extracted, first in the cold and then by the aid of heat, the oil obtained by the latter process being coarser and of less value. After the middle of May there is comparatively little fishing with open boats, and the landsmen return to their farms. Smack fishing then begins, and the vessels used vary in size from 20 to 50 tons, sloop or schooner rigged, and are for the most part old English, French, or Danish vessels. They carry twelve to twenty men, who fish entirely by hand line. The fish is gutted and salted as caught, the livers, sounds, and roes being preserved, and the heads also, when possible. Each fisherman marks every fish he catches, and at the close of the fishing each man's catch is sorted out and weighed separately, and along with the proportionate quantity of livers, sounds, and roes is divided into two equal parts, the fisherman getting one and the owner of the ship the other. The owner supplies the lines, hooks, &c., used, and provides the men with a portion of their food. French vessels fish to a large extent round the coast of Iceland, their average catch being considerably more than the total fishing of the Icelanders; and English, Norwegian, and Faroese smacks fish in Icelandic waters in considerable numbers. Herring fishing has, of late years, assumed considerable importance on the North and East Coast of Iceland, where it is, however, for the most part in the hands of Norwegians, comparatively few Icelanders being engaged in the fishing, though a large number find employment in the curing establishments. There are over 2,000 Norwegians engaged in the Icelandic herring fishery, and about 200 sailing vessels and steamers are employed in bringing salt and other goods to Iceland, and conveying the cured herrings to Norway, Russia, and Germany. The Norwegian method of fishing by drag nets is exclusively followed. Shark fishing is carried on to a considerable extent, especially on the north and west coasts, both decked vessels and open boats being used in this fishery. The species of shark caught is the *Squalus borealis*, and the industry is pursued solely for the sake of the oil yielded by the liver, the rest of the carcase being usually thrown away, though sometimes the flesh is preserved for food. The sharks vary much in size, running up to eighteen or twenty feet in length, and four to five in diameter through the thickest part of the body, and the yield of oil by each liver varies from four up to fifty gallons. Rich livers yield two-thirds of their bulk of oil, poor ones only about one-half. The vessels used in shark fishing are for the most part small schooners of thirty to fifty tons burthen, manned by eight or ten men. The usual fishing season is from January or February till August. During the winter months the sharks frequent shallow waters, and are found about twenty miles from land in fifty fathoms of water or thereabouts; in summer they seek deeper waters, and are caught at a distance of about one hundred miles from the coast, in a depth of two hundred fathoms. A hook, twelve to eighteen inches long, baited with horse flesh and seal blubber, weighted with an eight pound sinker, and attached by a couple of yards of strong chain to a line, is used, and is allowed to hang motionless about a couple of fathoms from the bottom. As soon as the shark is drawn up to the surface, harpoons and lances are struck into it, and the spinal column is cut. Large hooks are fixed into the body and chains passed round it, and thus secured, it is cut open and the liver extracted. The livers are brought ashore, and stored in vats till the solid matters have settled to the bottom, the more fluid portion is then melted in iron pots over an open fire. By this process the liver yields about two-thirds its bulk of a coarse dark-coloured oil. Of late years refining by steam has come into use, and the liver is melted as fresh as possible. By this means a finer lighter-coloured oil is obtained, but the yield is less. The crews of vessels engaged in shark fishing are paid about fifty-five shillings a month, with a premium of sixpence per barrel of liver; the captain gets two shillings and threepence per barrel on the first hundred barrels of the season's catch, and three shillings and fourpence per barrel on the remainder.

THE JUNGLE PRODUCTS OF BORNEO.

Consul-General Leys, writing on the trade, commerce, and productions of North-West Borneo, says that the chief articles of jungle produce, in which a large export trade is carried on, are gutta-percha, india-rubber, rattans, and birds' nests. Gutta-percha is the inspissated juice of tall forest trees belonging to the natural order *Sapotaceæ*. Various kinds and qualities of gutta are afforded by various sapotaceous trees, but the pure red Bornean gutta is yielded by the species *Dichopsis gutta*. Other species of the genus *Dichopsis*, however, yield guttas, which, being of inferior quality, are frequently mixed by the native collectors with the more valuable red variety. This red variety is obtained from red and rough-stemmed trees, which are generally found growing among old jungle on hill-sides to a height of from 100 to 150 feet. The following is the method employed by the natives in collecting the raw product:—On finding a tree old enough to be cut, one having a diameter of about twelve inches, they fell it, cut off the top, and ring the bark at distances of about a foot. The sap for two or three days gradually drains away, and as it does so is collected in any convenient vessels, such as leaves, cocoanut-shells, &c., from which receptacles it is transferred to a pot and boiled for the space of half-an-hour with a little water. The milk is boiled to prevent it from hardening on exposure to the air, as if allowed to do so it becomes comparatively valueless. It is difficult to estimate the average yield of each tree, as the quantity varies according to the size of the tree and time of the year, the flow of sap being greatest when the tree is producing most leaves; but a small tree will generally yield a quarter of a picul, the picul being equivalent to 133 lbs. avoirdupois, while the largest may yield as much as three quarters of a picul each. The value of the red gutta varies, according to its purity, from 40 dollars to 80 dollars per picul. Another species of *Dichopsis* yields an inferior gutta of a white colour. This species has a smaller growth, attaining a height of from 50 to 60 feet, and a slightly different foliage. It yields proportionately less gutta, only about twenty-six pounds per tree. India-rubber, or caoutchouc, is obtained from three varieties of rough-stemmed woody climbers or *manungans*, which attain a length of over 100 feet, and a thickness of about eight inches. The juice is obtained in much the same way as gutta, and is prepared either by boiling like gutta, or by steeping in a solution of salt. The wasteful method of collecting guttas and rubbers has naturally caused an exhaustion of the supply from the more accessible districts; the rubber trees are not, however, so thoroughly exterminated as the gutta trees, owing to the greater tendency of the former to be reproduced from suckers, from cuttings of the stem taking root accidentally, and from the fruit which, being edible, is much sought after by monkeys, birds, wild pigs, &c. Rattans, or canes, are the stems of various species of *Calami*, which are found in profusion throughout the whole of North-West Borneo. Birds' nests, well-known as the edible production of the Indian swallows, are found principally in the water-worn limestone and sandstone caves that exist in considerable numbers all over the district of North-West Borneo. Consul-General Leys says, "although highly esteemed by the Chinese as a luxury in health, and as having curative qualities in sickness, I believe that these birds' nests have no more nutritive or medicinal value than so much wholesome isinglass, which substance they strongly resemble in every way. Many very absurd theories have been mooted as to the way in which the substance forming the nest is procured by the bird. I am strongly inclined to believe that it is formed from the saliva of the birds—an opinion founded chiefly on the fact that the saliva-producing glands are, during the nesting season, always immensely enlarged, and evidently in very unusual functional activity. When it is remembered that a viscid secretion is usually found covering the inside of the mouth and the throat of birds—living as the swallow does, on small insects caught while on the wing—and that the nature of their food is peculiarly fitted to supply the substance of which the nest is chemically composed, and that the nest, though strong, is very small, thin, and light, such a theory is more probable than one would suppose." It appears, from the import and export returns of Borneo for the year 1882, that the value of gutta-percha and india-rubber exported during that year amounted to £62,600, of rattans £24,500, and of birds' nests £10,000.

SUBSTITUTE FOR PIPE-CLAY IN PRINTING.

Although in most reserve colours, pipe-clay has been replaced by other substances (such as sulphate of lead, chalk, &c.), there are certain colours in which it has been retained, notwithstanding its disadvantages. Amongst these is the reserve white which accompanies rat-orange, as also wool and silk printing.

With the object of discovering a substitute for pipe-clay, Herr Breuer has called attention (according to *Dingler's Polytechnic Journal*) to the properties of silicate of lime and magnesia, but these substances, by reason of their crystalline properties, are not well adapted to the purpose named. Ordinary white starch is, however, much more suitable, and this article seems likely to replace pipe-clay in wool and silk dyeing, and in the ordinary reserves. It is applied in the following manner:—White starch of the best quality is finely divided in a little water, and the paste thus obtained is mixed cold with the prepared colours or with the thickening substance used to weaken them. The reserves prepared in this way with rat-blue, print very well, and possess the same reserving power as those prepared with pipe-clay. For wool and silk printing they likewise have the special advantage, that in hand printing they allow of effective gradations of tone. In roller printing they do not injure the ductor and do not scratch the rollers, while the colours produced are clear and well marked.

The quantity of starch may be from 9 to 14 ozs. per litre (1¾ pint), without any fear that the steamed colours will be hard and brittle in consequence of the steam swelling the starch. These colours wash as well as those without the addition of starch, and give purer tones than the latter. As the price of the starch used is higher than that of pipe-clay, the improvement has no economical advantages, but this is compensated for by the advantages which have been explained.

General Notes.

Carriage of Petroleum on the Italian Railways.—The Italian Government have recently sanctioned the use of tank-cars on the railways for the carriage of petroleum in bulk, and it will now be possible to effect a considerable saving in time and freights, not only from the ports of Genoa, Venice, and Leghorn, but also to towns in Switzerland and Southern Germany.

Toughening Paper.—A plan for rendering paper as tough as wood or leather has been recently introduced on the Continent; it consists in mixing chloride of zinc with the pulp in the course of manufacture. It has been found that the greater the degree of concentration of the zinc solution, the greater will be the toughness of the paper. It can be used for making boxes, combs, for roofing, and even for making boots.

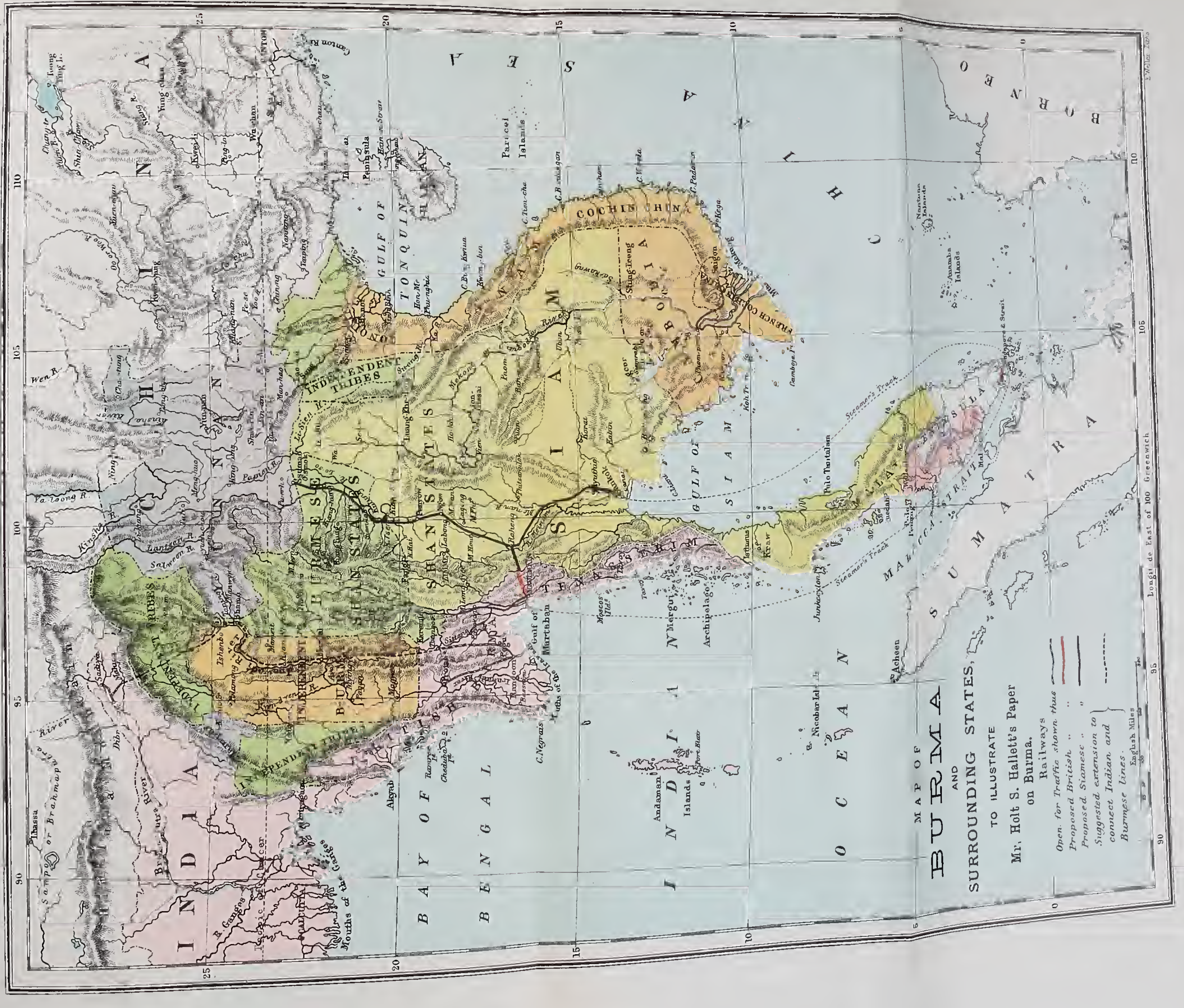
Electric Railway on Mont Saleve.—A concession has been granted by the Swiss Government to a firm of electrical engineers at Geneva for making a railway up Mont Salève, near that city. The line will be laid with a central rack, very similar to that of the Righi railway, but the toothed pinion on the locomotive which gears into it, instead of being driven by steam, will be worked by electricity.

Railways in Brazil.—According to the *Brésil* the total length of the railways of the Brazilian Empire is 8,123 kilometres (5,036 English miles), of which 6,132 kilometres (3,802 miles) are opened for traffic, and 1,991 kilometres (1,234 miles) are still in construction. The railways belonging to the Government have a length of 1,457 kilometres (903 miles), and represent a value of about £11,440,000 sterling. Of these the Don Pedro is the most important, measuring upwards of 700 kilometres (434 miles), and representing a capital of about £8,000,000 sterling.

Oriental Carpet Manufactures.—Since the opening of the Poti-Tiflis-Baku Railway the export of carpets to Europe from Central Asia has been considerably developed. According to various Armenian journals, French and English agents have established themselves in Tiflis, in order to purchase on the spot carpets for export to Western Europe. Consequently some important Persian factories have been opening branch establishments near those points, in order to be in the track of the business. The raw material is still obtained from Persia, as the inhabitants of that country have particular methods for imparting to the wool thefineness and brilliancy for which it is noted.

Edinburgh International Exhibition, 1886.—At this Exhibition, which will be opened in May next, special attention will be paid to the Fine Art Section, which is expected to contain works by the first artists not only of Scotland but also of England and the Continent. The part of the building set apart for the section is the Picture Courts surrounding the permanent buildings forming the main entrance to the Exhibition, which have a total length of 600 feet and a width of 300 feet. The doors from this court will open into the grand central court, 260 feet by 60 feet, in which concerts and bands will perform during the day and evening. There will be an Art Union in connection with this department, in which the winner will be allowed to select one of the pictures on the walls.

Exhibition of Windmills and Pumping Machinery at Lecce.—An International Exhibition of pumping machinery and other mechanism for raising water for drainage, irrigation, and other agricultural purposes, was opened on the 15th October, at Lecce. The utilisation of wind power forms a special feature at this exhibition. The programme comprises the following classes:—1. Tubular wells (Abyssinian) and apparatus for making them, pumps, &c. 2. Boring tackle, tools and implements, used for obtaining water and for sinking artesian wells. 3. Wind motors and their application to machinery for raising water. 4. Scoop wheels, chain pumps, hydraulic rams, archimedean screws, pulsometers and pumps of every description. 5. Drawings for projects of irrigation works, likely to prove of public utility in the provinces of Lecce, Foggia, and Bari.



MAP OF

BURMA

AND

SURROUNDING STATES,

TO ILLUSTRATE

Mr. Holt S. Hallett's Paper on Burma.

Railways

Open for Traffic shown thus	—
Proposed British "	🟥
Proposed Siamese "	—
Suggested extension to connect Indian and Burmese lines.	- - -

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All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

NOTICES.

JUVENILE LECTURES.

The first of the two Juvenile Lectures on "Waves" was delivered by Prof. SILVANUS THOMPSON, on Wednesday evening, the 30th ult. The lecturer began by explaining what a wave actually was, and described the different classes of waves, longitudinal waves and transverse waves, or waves of compression or expansion. He showed by experiments how visible waves, such as waves in water, belonged to the former class, waves by which sounds are transmitted being of the latter. He then showed how waves of different periods might reinforce or weaken one another, and then explained and illustrated the phenomenon of interference, showing how, in the case of musical sounds, "beats" were thus produced, when, for instance, two tuning-forks were thrown slightly out of unison by loading the prong of one. It was shown how a tuning-fork could record its vibrations on a piece of smoked glass rapidly drawn past it. This led up to a description of the phonautograph, by which a visible record of spoken sounds could be obtained, and the phonograph, by which the sounds themselves could be repeated. The lecture was fully illustrated by a great number of experiments.

The second lecture will be delivered on Wednesday evening next, 6th inst., at 7 p m.

COVERS FOR JOURNAL.

For the convenience of members wishing to bind their volumes of the *Journal*, cloth covers will be supplied post-free for 1s. 6d. each, on application to the Secretary.

SUGAR.

By G. Buchanan.

The sugar-cane had, and not so very long ago, the monopoly of sugar production. The enjoyment of a monopoly is seen, only too often, to be inconsistent with progress; and the sugar-cane industry continued to be carried on in the old-fashioned way, with unconcern and disregard for the development of a rival product. The magnitude to which the latter has attained so recently and suddenly, seems almost abnormal. If it be as permanent as great, the planter, it is pretty plain, will have to take special care, or leave his place to ruin. Coffee and cotton have ceased in our West Indian colonies, are we to acquiesce quietly in the increased loss of the sugar also? The cane is not beaten on its merits. No agricultural product, it used to be said, gives a return equal to that from a good sugar estate. And when we see how much has been accomplished by its favoured rival the beet, it would be unreasonable to doubt the capability of the cane, with like invention in machinery, selection of seed, and technical skill in workmen, to fulfil a similar success. All classes would benefit by an increased supply of cane-sugar, and energetic workers ought not to let the country be dependent for price on the adventitious supply of beet. The over production of beet-sugar in Germany, which ensued from the opportunity of making large profits under the system of sugar duties and drawbacks, will, by the attending abasement of the price, and from which it is probable there never will be a complete recovery, reduce the area sown for the coming and succeeding crops, and the sowings are likely to be diminished in another way. The German Government, it is understood, are not satisfied with the share of the profits of the beet-sugar manuufacture that accrues to the State, and have in contemplation the raising of the duty from 80 pfs. to 93 pfs. per centner, or hundredweight of roots. The drawback upon export of the sugar to be kept as it was, on the basis of an assessment of 10 marks per centner of sugar made. This indicates that 10¾ cwt. of roots will then be taken officially, instead of 12½ cwts. as formerly, to make 1 cwt. of sugar. And the proposed increase of tax, if sanctioned by the Reichstag, would thus, in years of ordinary fertility, greatly lessen, if not do away with, the bounty on export, which has been so long and loudly complained of in this country, as a grievance. Though bounty, it was not in the meaning of a premium from the State to encourage sugar-making, but simply a benefit to the producers from their own skill and ingenuity, obtained by turning to profit the chance they had of getting more sugar from the roots than the excise assessment; a thing that has happened before now nearer home, when the march of improvement has outstripped legislation in such matters. The advantage taken of the Netherlands' system of duty by classification of colour, to bring beet-sugar from Germany, artificially coloured in the lowest class, and ship it for drawback, has now been put a stop to. And the bounty obtained in the United States from the drawback being unchanged when the duties were altered, cannot continue long after public attention is directed to it. But there is not the objection there is with beet to receive pure granulated cane-sugar from our friends there, if they please to supply us at a cheaper rate than they pay themselves. However, the returns of the last two seasons show that the beet yields a larger percentage of sugar than is represented by the figure 10$\frac{3}{4}$; for the last two years were good and plenteous years, and if the years to follow should happen to be characterised by the same exuberant richness and weight of roots, our cane-sugar growers and refiners will find things more comfortable than before. The enterprise of the beet cultivators and fabricants, and the better modes of procedure followed in their work, have given them a perfection of process against which the cane-sugar producers will find it hard to contend. But the excellence attained by the former is perhaps now at its best, both in cultivation and manufacture, and in the struggle to recover their old supremacy in the markets, the latter will have the advantage of knowing the lessons taught by the practice of their opponents. Here "our antagonist is our helper."

In any near view of the case, the enrichment of the sugar-cane naturally comes first for consideration. There are more than half-a-hundred varieties of the plant, differing much in the quantity of fibre and the amount of sugar they furnish. And the advantages of selection and good cultivation of the fittest is shown by the immense improvement made in the beet, which has, by the use of Vilmorin seed and high farming, been brought to yield, it is said, one cwt. of sugar from 8·34 cwt. of roots. This was in Germany, where they may be, it will be readily owned, great in theory and speculative research, but are held to be somewhat wanting in the practical acumen we note complacently in ourselves, which enables us to carry out a thing, when once it is taken up, and leave foreign nations behind. The object is sugar, and experience says much for the system of cultivation upon which the German fabricants lay stress. It requires the farmer to content himself with growing a comparatively small crop of roots per acre, and to develop the sacchariferous quality of what he grows to the utmost by "forcing." The care for quality rather than quantity in the cultivation, effects a saving in the labour and fuel that would otherwise have to be expended in manufacturing a large crop of watery, unsweetened roots. To the planter, his big crop of canes is likewise, as regards time or money, a heavy charge and great inconvenience. To speed the work and labour of crushing, the three-roller steam mill was designed, and it made quicker work with the canes, but not better work than the two-roller cattle mill, which has been known to squeeze out sixty per cent. of juice. To get better results it was screwed up, and strengthened, and enlarged, and more rollers added. Yet the outcome of all the improvements is a roller mill, and nothing more. It is still an unsettled question how far pressure may be exerted commensurable with profitable effect. And invention has not sought out a more perfect instrument. To make a reduction in the number of canes, and no diminution in the weight of sugar per acre, would answer well for the planter. And of his wishes there can be no doubt, could these be realised. Nor is the thought utopian, for it appears that in Louisiana, two or three years ago, an overflow, and consequent loss of growing cane, left the planters with little hope of regaining expenses, but the canes, though short and slim, were found to contain an unexpected quantity of saccharine matter, and the result was an agreeable surprise. The sugar in the cane, it seems to be agreed, is not drawn from the earth, but is elaborated from the carbonic acid in the air by the direct influence of the sun on the green leaves. Thus Nature herself points out to us the need of room and space for the growth of the cane in all its fulness, and that too close planting, by keeping out sunshine, prevents a healthy vegetation. Without a free access of air and sunlight, the power of the plant to produce sugar is weakened. And since there is no exhaustion of the soil by the formation of sugar, and plants take up only the nourishment they actually want, no more manuring is demanded than will restore the wastage of the other matters taken up from the soil by the crops of cane raised from it. If canes are ill-fed, a low vitality might not be able to withstand disease. And this is not a groundless apprehension, for in Java it has lately been discovered that the growing canes were affected by a disease, the precise nature of which is as yet not known.

Single crushing is inadequate to express the full amount of juice from the cane, and it was supplemented by double crushing. But neither did double crushing suffice, and then the megass was drenched with water and steamed preparatory to the second pressure. But even so, imbibition did not effect a saving of all the remaining sugar; there is left from 10 to 12 per cent. in the present refuse. The next step is diffusion, pure and simple. In this process the water put into the first vessel with the slices of cane is weight for weight the same, and takes out one half the sugar from the first into a second vessel, containing other slices of cane, from which it takes out one-fourth the sugar into a third vessel, also holding fresh slices, and so on until in the sixth vessel the water has in solution the whole amount of sugar, excepting about 1$\frac{1}{2}$ per cent. The sugar, as it is taken out, is replaced by water in the slices of cane. By this is manifest the excess of water in diffusion juice beyond what is in mill juice. With more changes of vessel the difference would decrease, but there would always be an excess of water to be evaporated. Practical working is said to have shown this to be from 15 to 20 per cent. On the other hand, in the mill, the water imbibed by the megass previous to the second crushing, is not far short of half the amount of juice contained originally in the cane, if not as much as the quantity expressed by the first pressure, and therefore an excess of from 50 to 60 per cent. What then becomes of a chief objection to diffusion, the great diluting of the cane-juice. The dilution is greater by imbibition, and yet one moiety of the sugar got by imbibition pays the cost. The other moiety is found money. Much capital is fixed in mill machinery, doubtless, and it remains to make the most of it. The greater number, by far perhaps, of planters work with borrowed money, and they are not at present likely to obtain further advances, in order to make changes, or set up new apparatus. Yet the time will come for them, or new men, to try increased production, by using the most recent and approved methods and appliances. The benefit to be derived from new inventions is not always immediate or certain. But the cane-sugar producers have had the beet-sugar producers in the way before them, to bear the burden of experiment and demonstration. Cane-sugar, it will not be gainsaid, can be, even now, produced at less cost than beet-sugar. The varieties of soils yielding, some more, some less, and the diversities of mills working, some better, some worse—make it almost impossible to strike the balance of expenditure. But the make-weight on the side of the cane will be equal, it may be fairly assumed, to 2s. per cwt., the supposed bounty on beet, if not more. Nor will it be denied that there is more room for the cane than is left for the beet, to develop and improve, in growth and manufacture. The beet has no future to look to, in comparison with the possibilities in view of the cane.

But the cane-sugar planter and the merchant have little encouragement given them, to embark more capital and skill in the enterprise of the production, by the refiner who has the distribution of the sugar. Cane-sugar or beet-sugar it is all "David and Davie" to the refiner. He mixes the one with the other in the manufacture of loaf or lump sugar, and says there is no difference. The mixture may even seem to be an improvement, like chicory with coffee, to debased tastes; and unfortunately there is no pure cane-lump to be had now-a-days to correct the standard of taste. Beet-sugar is, nevertheless, inferior to cane-sugar in many ways. It is not equal in sweetness, the crystals are smaller, and it is of a duller more opaque colour. To brighten up the colour, the practice of "blueing" was borrowed from the laundry, and as one's linen so the sugar is imbued with a factitious liveliness of appearance. Cane-sugar can do without this artificial aid, and the blueing might be for a sign to the consumer which of the two sugars to choose. The treacle too, or drainage, from the refined beet has not the sweet smelling savour of that from the cane, and though in the form of golden syrup it is made enticing to the eye, it is neither so pleasing to the taste, nor so wholesome as pure cane syrup. And treacle is, or was preeminently the sweet of the children of the poor. The sugar planter has perhaps no claim on the refiner for active aid and assistance in his contest with the beet grower. But a business feeling, it might be supposed, would incline the refiner towards the exercise of a benevolent neutrality. And yet the refiner is so inconsiderate as to subsidise the common adversary of himself and the planter. For what else is it but a subsidy to give money to receive goods in aid of his trade. If the refiner will be apparently so impolitic, it is hardly reasonable in him to complain of the business going out of his power and failing him. But it is shrewdly thought that we cannot be doing a very unprofitable trade with cane-sugar at the reduced prices so long prevalent.

The conclusion of the whole matter is that we have been unable to hold our own, and have retrograded. But the supremacy that has passed into the hands of the beet-sugar producers cannot be left unchallenged. It will not be creditable to the spirit and enterprise of this country, the most deeply engaged of any in the cane-sugar industry, if the technical perfection exhibited in all the work of beet-sugar production is not attained to in cane culture and manufacture. The beet-sugar cultivators and fabricant have secured a firm footing, fixed on and buttressed by the agricultural and fiscal systems of their country, but none can doubt that with a long pull, a strong pull, and a pull altogether by planter, merchant, and refiner, the tug of war would end in favour of the cane.

COLONIAL AND INDIAN EXHIBITION.

The Nizam of Hyderabad has appointed Major Nevill, commander of the State regular forces, to be his commissioner for this Exhibition. The consignment of the products of Bengal and the North-West Provinces will be despatched on the close of the local exhibitions at Calcutta and Lucknow; those from Cashmere and Madras have been already forwarded, and most of the other provinces are displaying considerable activity. The Agricultural, Forest, and Revenue Departments are assisting in the ethnological and economic collections; and it is expected that these exhibits will be shortly on their way to England.

COMMERCE IN TRIPOLI IN 1884.

The total value of the exports and imports in Tripoli during 1884 amounted to 15,344,000 frs., of which 7,310,600 frs. for imports, and 8,033,400 frs. exports.

The number of merchant vessels that entered the port of Tripoli during the same year was 618, amounting to 196,909 tons registered.

Amongst the manufactured goods, to the value of 276,000 frs. were imported from England, and from 417,000 frs. from other countries. The English goods were for the greater part cotton, and especially calicoes, of which large quantities are consumed throughout the country. Other goods, such as gold and silver brocades, silks and satins of bright colours, are in great demand.

Rice, to the value of 225,000 frs., is principally imported from Italy, and the greater part is used for the army, very little being used by the natives.

The imports of iron to Tripoli from Malta amounts in value to 110,500 frs., the greater part being supplied from that island. Belgian merchant bars are preferred to English; tools are supplied from both countries, but nails are chiefly furnished by Belgium. Glass-ware, such as bottles, glasses, &c., are chiefly imported from Belgium, Marseilles or Malta, which latter places supply crockery, lamps, &c.

Groceries, such as sugar, coffee, &c., are supplied to the value of 1,250,000 frs., either from Malta or Marseilles.

The principal articles of exportation are ostrich feathers, which are brought from the interior by caravans, but are chiefly sent to England or France, and represent a value of 4,600,000 frs.

Ivory also forms an important trade, and in 1884 the exports amounted in value to about 200,000 frs.

The value of Esparto grass, exported principally to England, was 1,736,000 frs.; woollen goods were exported to the value of 259,000 frs. About a quarter of the population are engaged in this industry, and a ready sale is found for carpets, blankets, &c., both in the country, and for export.

EMERY MINES OF ASIA MINOR.

Although emery stone is found in nearly all parts of Asia Minor, and not unfrequently in the remote and almost inaccessible regions of the interior, where the natural obstacles are too great to offer any inducement to the miner, the principal mines are confined to the districts of Thyra and Aidin. These mines, says Consul Stevens, of Smyrna, are the Tchavus, the Hassan Tchavuslar, the Aladjali-Tchiflik and Kourchak, the Halka, the Akdere, and the Gumush Dogh. There is another mine near Milassa, the stone from which is brought for shipment to a place on the coast called Kuluk, near the Gulf of Mendalio, and is either shipped direct from that place to foreign markets, or brought to Smyrna in small sailing craft for re-shipment. When well picked and freed from unsound ore and rubbish, the emery from the Tchavus, Hassan Tchavuslar, and Aladjali-Tchiflik mines is of good and nearly equal quality. The Akdere stone is not so much sought after, while that excavated near Milassa, the larger part of which finds purchasers in the United States, is of inferior quality, the grain being smooth and a considerable quantity of magnetic iron entering into its composition. The amount of stone annually shipped from Smyrna to Great Britain, the United States, France, Germany, and Belgium, averages 7,000 tons, the relative quantity consumed in each country being in the order named. The process of extraction is as follows:—The mines are opened by wells and galleries, and the stone is obtained in most instances by blasting, gunpowder and dynamite being freely used to extract it from between blocks of marble or masses of granite. The overseers and principal workmen at the mines are Italians, who are paid at the rate of three shillings and sixpence a day, while the native workmen only receive about half this amount. The emery is picked daily at the mines as fast as it can be extracted, in some cases not one half the quantity being selected. It is then conveyed by camels to the nearest railway station, and from thence to Smyrna, where it is generally picked again previous to shipment. When the mines are situated on heights inaccessible to camels, the ore is brought down to the plains by donkeys, and if the pieces are too large to be carried by camels they are brought to the station in carts, drawn by buffaloes. The mines are worked upon the strength of concessions termed *firmans*, granted by the Imperial Government for a period usually of ninety-nine years, or in cases where the emery has been found on *nacouf* property, that is, property belonging to the Turkish religious institutions, by special permit of the department at Constantinople which administers the *nacouf* estates, and exacts payment to them of so much per quintal. A *firman* or concession during the period it is in force can be sold, transferred, and transmitted by inheritance, like other property in Turkey, provided due notice be given to the department of mines at Constantinople and authorisation formally obtained.

LACQUER WORK OF THE BURMANS.

The Burmese lacquer work is not unlike that of China and Japan, but is made exclusively of small bamboo strips. These latter are woven into circular boxes of all sizes, from betel-pouches to house-trunks. The first step in the lacquering is to smear the box with a mud containing (or not, according to quality) a proportion of the black varnish called *thittsee*, obtained from *Melanorrhœa usitatissima*. Next follow sun-drying, and polishing in a lathe with soft sandstone and water. A coat of the varnish, mixed with bone-ash, is then applied, and rubbed down; another coat, containing less bone-ash, and another rubbing down, succeed; then a final coat of varnish is polished, giving the box a smooth, brilliant, black surface. The pattern is put on in black and red. First, black lines are run round the box by a kind of style or point, fixed in a bit of wood or bamboo, so as to leave a slight projection, the point being charged with black varnish; on rotating the box in the lathe in contact with this style, the necessary black lines are produced in relief. These being completed, the box is entirely covered with a coating of a red paint made from vermilion ground up in a vegetable oil (*shantsee*), so thick as to conceal all the black lines. This dry, a rubbing down with rice-husks and water in the lathe removes the red colour from the prominent black lines. Any additional colours are successively applied, and the pattern developed by a steel style, pointed at one end and flattened at the other. The market value of the finished box depends on its elasticity and the fineness of the pattern. The best will suffer bending double, without injury to the lacquer; a 3-inch betel-box of this quality may fetch as much as a couple of guineas.

CHEMICAL TRADE IN 1885.

Soda, one of the leading articles of the northern chemical trade, is at the present time at about the lowest price known in the history of the trade, and the competition with some of the foreign makers seem rather increasing than decreasing. At the beginning of the present year the price of crystals on the Tyne was £2 9s. per ton, and it rose 3s. to 4s. in the height of the shipping season, but it has now sunk to £2 1s., a price which entails a loss estimated at from 4s. to 8s. per ton. The price of soda ash has fallen to a fully corresponding extent. It is believed that the extent of the production has been reduced, and it is well known that the associated makers have been trying by combination to prevent that great decline in price, but so far without success. The competition has already crushed out one of the smaller manufactories on the Tyne, and is likely to crush out others unless there should be a change in the position of the trade. There have been some features which serve as a set-off to these low prices it is true, for the price of sulphur has been reduced considerably, and another of the raw materials—salt—has also been easier to buy; but these reductions are only believed to have slightly lessened the loss on the production of soda. The older process in that manufacture—the Leblanc process—is still universal on the Tyne, and every year the competition of the new ammonia process is growing keener, not only at home but abroad, so that less help than would formerly have been given is obtained from the cheapness of sulphur and salt. In the production of soda by the older process there is given out what was formerly a waste product, but is now a very valuable one—that from which bleaching powder is made. Owing to the reduced production of soda by the older process, and by the effect of a combination of the bleaching powder makers of the United Kingdom, the price of that article has been very materially raised of late years, and in the year 1885 the price has been fairly maintained over the whole of the year, for at the beginning the price was £6 5s., and at its end it is £6 per ton—a price which is fully 50 per cent. above that of a few years ago. So long as that high price is obtainable, so long will there be a production of soda, even at a loss, by the older process, and the maintenance of the price may be said to depend on the retention of the monopoly of the make by the Leblanc process, and the continuance of the combination of the makers. Bleaching powder is for the time the staff on which the chemical trade of the north depends, though there has been, and will be a considerable gain to the producers of chemicals in the north, owing to the large development of production of salt in South Durham. Prior to the utilisation of the stores of salt in South Durham, the bulk of that material was obtained from the Cheshire salt makers, and the price of the salt was almost doubled by the cost of its carriage to the Tyne. As yet the full benefit in price of the enlarged production of South Durham has not been obtained, the competition having been limited; but it is considered certain that the output of salt will increase. It may, however, lead to the production of soda in South Durham on a large scale, for there are now in successful operation alkali works at Port Clarence. The Tyne chemical trade seems, therefore, still menaced by the increasing competition in the alkali trade. Any general revival of trade would add to the demand for chemicals considerably; but the cheaper method of production in those districts where salt is procurable in the form of brine seems certain to leave to the chemical trade on the Tyne only the profit which remains on that article of which they still have the monopoly of the manufacture. The continuous fall in the price of soda, which was only a few years ago about £4 per ton, and is now about one-half that sum, has brought with it some attempt to minimise the cost of production; but it is difficult to do this as rapidly by the older process as by the newer one, and it is this new process, especially abroad, which seems gradually reducing the area for the sale of that article for which the Tyne chemical trade has long been noted—soda crystals.—*The Times.*

THE FORESTS OF FRANCE.

The United States Consul at Paris says that of all the forest wealth of France there only remain in round numbers 22,000,000 acres, the greater part of which is composed of woods of simple growth; there is, moreover, an almost equal extent of uncultivated grounds which are generally the remains of old forests that have been destroyed. From 1791 to the present time, the extent of woodland property has constantly decreased. The State owned in 1791, according to reports of that epoch, 4,213,088 acres; in 1795, 6,406,939 acres; in 1820, 3,001,362 acres; in 1830, 2,777,148 acres; while at the present time there only remain 2,389,887 acres. Since the year 1820, more than 741,342 acres of forest belonging to the State have been sold to private individuals. The tract of communal forests and of woodland owned by private persons has decreased in still greater proportion. For the last fifty years more than 1,112,013 acres of forests owned by private owners have been cut down. During the same period, from 1790 to 1880, Austria increased its forest area by 694,871 acres, and during the past twenty years the forests of Bavaria have gained 129,971 acres. The same progression is to be observed in Switzerland. From returns which have recently been published, it appears that France has only 99 square rods of woodland per inhabitant, while the average is, in Russia, 135 square rods, Bavaria 185, Wurtemburg 138, Baden 143' and Austria-Hungary 202. France therefore stands in a position of inferiority with regard to neighbouring countries. The French customs return show that while in 1830 the value of the wood imported only amounted to £850,000, it now exceeds £8,000,000, an increase of £7,150,000 in fifty years. The exports for the same period only increased to the extent of £1,280,000. Large quantities of staves are annually required by those engaged in the wine industry, and as the number of oaks of the proper size is insufficient to supply the necessary quantity, recourse is had to importation. It is stated that the average value of these articles annually imported into France, amounts to about £2,000,000. The imports of sawn timber exceed the exports by £579,000 for oak, and by £4,671,000 for pine, with an increase of nearly £1,930,000 over the preceding year. France now only produces from 900,000 to 1,000,000 cubic yards of pine. It imports from Sweden and Norway 130,000,000 to 160,000,000 yards of planks, valued at £3,088,000, and about 654,000 cubic yards of timber valued at £772,000. The total imports of wood into France from Sweden, amounted last year to £2,536,000, and from Norway to £1,018,000. Germany, from which France received in 1865 only £500,000 worth of wood, now sends about £1,389,000 worth. Germany also receives in exchange £96,000 worth of forest products, and supplies a great part of the French railway sleepers. Imports into France from Austria have also largely increased. In 1865, they only amounted to £1,270,000, whereas they now amount to £2,169,000. The staves manufactured in Croatia, Slavonia, Southern Hungary, and Russia, are now reserved almost exclusively for exportation to France, and these countries supply France with over 8,000 cubic yards of staves. France receives from Switzerland, timber to the value of £798,000, and the value of her exports to that country only amount to £31,000. Italy, though it is poor in woodland, exports to France about £355,000 worth of timber, and only imports from that country about £69,000 worth.

ORANGE AND LEMON CULTIVATION IN SICILY.

Consul Woodcock, of Catania, states that oranges and lemons are designated, in Sicily, *marina* and *montano*, the former growing in the lower altitudes near the sea, and the latter on the mountains. The montano, or mountain fruit, is the choicest, and commands the best prices in the market, but the crop is not so sure, owing to the frost. The marina orchards bear more abundantly, and the crop is more certain. In commencing an orange or lemon orchard, the following is the method adopted:—First, the seed of the bitter orange is planted, and when the young plants are a year old, they are transplanted. When they have grown to be about one inch in diameter, that is, when they have attained the age of three to four years, they are again transplanted, and placed in the orchard where they are intended to remain. The tops of the young trees are then cut off about four feet above the ground, and when they have taken firm root, the best varieties of the orange and lemon are budded upon the stock. Two buds are generally inserted, and upon opposite sides of the plant. From these buds, branches shoot out, and when a quarter of an inch in thickness, become of a reddish colour. The distance to be maintained between the lemon trees in the orchards depends upon the situation of the ground, and conditions of soil and climate; usually it varies from thirteen to nineteen feet. When the soil is loose, rich, and easily cultivated, the lemon trees are planted at least nineteen feet apart, as they will then grow luxuriantly and attain considerable size. The distance maintained between the orange trees is from thirteen to fourteen feet, and this varies in accordance with the situation and quality of the soil, as in the case of the lemon. The ground in the orchards between the trees is always cultivated, and great care is taken to keep it scrupulously clean. The soil is worked at least five times a year, commencing in March and ending in October. When the trees are young and small it is not considered necessary to work the soil, as it is believed that the vegetable growth protects the young plants from the too powerful rays of the sun. The annual cost of cultivation in the best orchards per hectare (the hectare being equivalent to 2·47 acres) is estimated at about £30, but where extraordinary outlays are necessary, such, for instance, as is incurred when there are streets running through the orchards, as is often the case in the lava covered soil of Sicily, or through the necessity of obtaining steam power for irrigation, the cost per annum is sometimes as much as £80 per hectare. On the average, a lemon tree produces in Sicily one thousand lemons annually, and an orange tree six hundred oranges, and cases have been known where trees have produced ten times this amount of fruit. The trees are subject to various diseases. A parasite growth of a fungus nature frequently appears upon the bark, and the lemon tree is more subject to this than the orange. This growth, after a heavy rain, or after being soaked in water, can be removed by scraping. The fruit of both the orange and lemon tree is also sometimes injured by a small insect which makes its appearance at the beginning of summer, and commences its work of devastation by depositing its eggs in the fruit itself, and these develop into grubs, which entirely destroy it. As a preventitive, tar water and water slightly tinctured with kerosene, are used to wash the leaves and fruit, and soda ash is also frequently employed. In picking the fruit for exportation, which is usually done by hand in the month of November, the greatest care is taken to avoid bruising or injuring it in any way by rough handling, and it is then placed very gently in baskets lined with cloth. The stem is left on the fruit, cutting it about a quarter of an inch from the surface of the fruit. Before placing the fruit in the boxes, all insects and other injurious matter are removed. The boxes generally used are capable of holding from two hundred and fifty to three hundred and sixty oranges or lemons, and are made with a partition in the centre. They are lined with common silk paper, and each orange or lemon is encased in the same kind of paper before being placed in them. The boxes are not made air tight, but interstices are left between the boards for ventilation. Lemons gathered in the month of November, and thus packed, are supposed to keep without spoiling for six months, but oranges will not keep so long.

INQUESTS ON FIRES.

According to *The Times* it is under consideration by the City Corporation to obtain powers to re-introduce the ancient custom of holding courts of inquiry as to the cause of fires occurring within the City boundary. The subject has been under the consideration of the authorities for some time past, but their attention has been directed towards it more particularly in consequence of the fires the origin of which is "unknown" reaching the high per-centage of 25. Formerly the coroners throughout the kingdom held inquests, not only upon deaths and fires, but upon burglaries and robberies. Although the practice had been discontinued some four centuries, it was re-introduced in 1845 by Mr. Serjeant Payne, who held altogether some 70 inquiries. The question was much debated as to its legality and also as to its utility, but it was finally settled in 1860, when Lord Chief Justice Cockburn, Mr. Justice Wightman, and Mr. Justice Blackburn decided that the coroner of Manchester had no power to hold inquests on fires unless it was specially given him by the Legislature. This decision applies to the whole of England except Northumberland, where by custom the holding of inquests on fires has continued without interruption from the earliest times. The principal fire insurance companies are in favour of the coroner being vested with the additional power, as is also the Metropolitan Board of Works. Captain Shaw, while admitting the desirability of the establishment of fire inquests, is afraid there are insurmountable difficulties, and among them expense, in the way. At the next meeting of the Court of Common Council a motion recommending the institution of a Royal Commission on the whole subject will be discussed.

This subject has been discussed at meetings of the Society of Arts. After the reading of the late Mr. Cornelius Walford's paper on "Destruction of Life and Property by Fire," on February 28th, 1883; Mr. Serjeant Payne's letter on fire inquests was read (see *Journal*, vol. xxxi., p. 371); and at a meeting held by the Society on May 31, 1883, the following resolution was passed:—"That in all cases where serious loss of property has occurred through fire, provision ought to be made for holding an official inquiry by some competent authority."

General Notes.

◆

Basic Process.—The following figures give the progress of basic or Thomas-Gilchrist process for ten months ending September 30th, 1885. The total make of steel and ingot iron made from phosphorus pig during this period amounts to 945,317 tons, being an increase over the make of the previous ten months of about 10 per cent. It is noticeable that of this make no less than 600,183 tons was ingot iron containing under ·18 per cent. of carbon, used for wire, sleepers, tin plates, tubes, boiler and ship plates, &c. The makes of the various countries are as follows:—

	Tons.		Tons containing under ·18 per cent. of carbon.
England	145,707	of this	70,803
Germany and Austria	617,514	,,	424,868
France	130,583	,,	62,300
Belgium and other countries	51,514	,,	42,118
	945,317		600,183

MEETINGS OF THE SOCIETY.

ORDINARY MEETINGS.

Wednesday evenings, at Eight o'clock:—

The following Dates have been fixed.

January 13.—"Museums for Trade Patterns." By Wm. H. Ablett.

January 20.—"Results of Experiments on Mechanical Motors for Tramways made by the Commission at the Antwerp Exhibition." By Captain

Douglas Galton, D.C.L., C.B., F.R.S. Sir Frederick Abel, D.C.L., C.B., F.R.S., Chairman of Council, will preside.

January 27.—"Machinery in Mines." By Henry Davey. Sir Frederick Bramwell, F.R.S., will preside.

February 3.—"Artistic Bronze Casting." By George Simonds.

Dates to be Hereafter Announced:—

"The Treatment of Sewage." By Dr. C. Meymott Tidy.

"Calculating Machines." By C. V. Boys.

"Domestic Electric Lighting." By W. H. Preece, F.R.S.

"The Experiments with Lighthouse Illuminants at the South Foreland." By E. Price Edwards.

Foreign and Colonial Section.

Tuesday evenings, at Eight o'clock:—

January 26.—"The Importance of a National Scheme of Emigration for the best interests of British Commerce." By Arnold White. The Most Hon. the Marquis of Lorne, K.T., will preside.

February 16.—"The Aspect of Affairs in the Interior of South Africa." By Lieut.-Col. Sir C. Warren, R.E., K.C.M.G.

March 23.—"The Commercial Progress of New South Wales." By Edward Combes, C.M.G.

March 2; April 13; May 18.

Applied Chemistry and Physics Section.

Thursday evenings, at Eight o'clock:—

January 28.—"Magnetism of Ships and the Mariner's Compass." By Wm. Bottomley, Jun.

February 11.—

February 25.—"Photography and the Spectroscope in their Application to Chemical Analysis." By Professor W. N. Hartley, F.R.S.

March 11.—

April 8.—

May 13.—"The Scientific Development of the Coal Tar Colour Industry." By Professor R. Meldola, F.C.S.

Indian Section.

Friday evenings, at Eight o'clock:—

January 22.—"Burma; the Eastern Country and the Race of the Brahmas." By J. George Scott (Shway Yoe). The Hon. Sir Ashley Eden, K.C.S.I., will preside.

February 19.—"Historical and Recent Famines in India." By F. C. Danvers, F.S.S., Registrar and Superintendent of Records, India-office. J. M. Maclean, M.P., will preside.

March 19.—"Experiences on the Afghan Frontier." By William Simpson. Col. Henry Yule, C.B., will preside.

April 2; May 7, 21.

The above dates are liable to alteration.

Cantor Lectures.

The Second Course will be on "Friction." By Prof. H. S. Hele Shaw.

Lecture I.—January 18.—The Friction of Solids.

Lecture II.—January 25.—The Friction of Fluids.

Lecture III.—February 1.—The Mechanical Applications of Friction.

Lecture IV.—February 8.—The Methods of Reducing Friction.

MEETINGS FOR THE ENSUING WEEK.

Monday, Jan. 4...Chemical Industry (London Section), Burlington-house, W., 8 p.m. 1. Mr. G. E. Davis, "The Enrichment of Coal-gas by Hydrocarbons." 2. Mr. C. T. Kingzett, "Notes on Russian Turpentine."

Medical, 11, Chandos-street, W., 8½ p.m.

Victoria Institute, 7, Adelphi-terrace, W.C., 8 p.m. (At the House of the Society of Arts.) Mr. W St. Chad Boscawen, "Historical Evidences of the Migration of Abram." With valuable readings from newly deciphered inscriptions.

London Institution, Finsbury-circus, E.C., 5 p.m. Dr. E. Freshfield, "Christian Constantinople."

Tuesday, Jan. 5...Royal Institution, Albemarle-street, W., 5 p.m. (Juvenile Lectures.) Prof. Dewar, "The Story of a Meteorite." (Lecture III.)

Pathological, 53, Berners-street, Oxford-street, W., 8½ p.m. Annual Meeting.

Wednesday, Jan. 6...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. (Juvenile Lectures.) Prof. S. P. Thompson, "Ether Waves and Electric Waves." (Lecture II.)

Archæological Association, 32, Sackville-street, W., 8 p.m. 1. Mr. J. Romilly Allen, "The Sculptures of the Norman Doorway at Abne, Yorkshire." 2. Mr. J. W. Grover, "The Discovery of the Monuments of the Atkins family at Clapham."

Thursday, Jan. 7...Royal, Burlington-house, W., 4½ p.m.

London Institution, Finsbury-circus, E.C., 7 p.m. Prof. Flower, "Cattle of the Past and Present."

South London Photographic (at the House of the Society of Arts), 8 p.m. Popular Lantern Display.

Royal Institution, Albemarle-street, 3 p.m. (Juvenile Lectures.) Professor Dewar, "The Story of a Meteorite." (Lectuee IV.)

Geologists' Association, University College, Gower-street, W.C., 8 p.m. 1. M. Ed Dupont, "Considerations on some Phenomena observed in the Devonian and Carboniferous Rocks of Belgium." 2. Dr. Henry Woodward, "Supplementary Note to his Paper on Wingless Birds." 3. Mr. E. T. Newton, "Note on the Large Bird from the Eocene of Croydon, found by H. M. Klaassen."

Friday, Jan. 8...National Society of French Teachers (at the House of the Society of Arts), 11 a.m. Annual Conference.

Astronomical, Burlington-house, W., 8 p.m.

Quekett Microscopical Club, University College, W.C., 8 p.m.

Clinical, 53, Berners-street, W., 8½ p.m.

Saturday, Jan. 9...National Society of French Teachers (at the House of the Society of Arts), 11 a.m. Annual Conference.

Botanic, Inner Circle, Regent's-park, N.W., 3¾ p.m.

Royal Institution, Abemarle-street, W., 3 p.m. (Juvenile Lectures.) Prof. Dewar, "The Story of a Meteorite." (Lecture V.)

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FRIDAY, JANUARY 8, 1886.

All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

NOTICES.

JUVENILE LECTURES.

In the second of the two Juvenile Lectures on "Waves," Prof. Silvanus Thompson dealt with waves of light and of electricity. Light waves differed from sound waves in that they were transverse instead of longitudinal. They were transmitted very much more rapidly, and their number per second was enormously greater. That they were, however, true waves could be proved by their exhibiting the phenomenon of interference described in the first lecture. It was shown by an experiment that by a slight retardation of a portion of the waves composing the beam of light behind the remainder, the waves could be made to annihilate one another, and produce darkness. Newton's rings were shown on the screen, and their cause traced to interference. The manner in which the light vibrations were propagated through the ether was explained, and the characteristic described which it was necessary that the ether should possess for the purpose, and which, therefore, it was assumed that it did possess. Some of the effects produced by polarising light were shown, and their cause explained.

In the second part of his lecture, Professor Thompson showed how connection could be traced between the waves of light and of electricity, and showed a number of experiments illustrating the action of electrical waves.

After the conclusion of the lecture, a unanimous vote of thanks was passed on the motion of the Chairman (Lord Sudeley), who spoke in warm terms of the beauty of the experiments which had been shown, and the clearness of Prof. Thompson's explanations.

Miscellaneous.

COLONIAL AND INDIAN EXHIBITION.

Her Majesty the Queen has expressed her willingness to become patron of the Exhibition. The following is a list of the Executive Commissioners appointed:—

A. Dominion of Canada.—The Hon. Sir C. Tupper K.C.M.G., C.B.
B. New South Wales.—
C. Victoria.—R. M. Smith, C.M.G.
D. South Australia.—Sir A. Blyth, K.C.M.G.
E. Queensland.—James F. Garrick, C.M.G., &c.
F. Western Australia.—The Hon. Malcolm Fraser, C.M G., J.P.
H. New Zealand.—Sir F. D. Bell, K.C.M.G.
I. Fiji.—
K. Cape of Good Hope.—Sir C. Mills, K.C.M.G.
L. Natal.—Sir W. C. Sergeaunt, K.C.M.G.
M. Ceylon.—A. N. Birch, C.M.G.
N. Mauritius.—J. Despeissis.
O. Straits Settlements.—F. A. Swettenham.
P. Hong Kong.—The Secretary to the Royal Commission (Sir Philip Cunliffe-Owen).
Q. British North Borneo.—Sir R. Alcock, K.C.B.
R. British Guiana.—S. H. Hawtayne.
S. West Indies.—A. J. Adderley, C.M.G.
T. West African Settlements.—Sir James Marshall.
V. Malta.—Sir V. Houlton, G.C.M.G.
W. Cyprus.—
X. Falkland Islands.—The Secretary to the Royal Commission.
Z. Indian Empire.—The Secretary to the Royal Commission.

The Hon. T. Risely Griffith, Colonial Secretary for Sierra Leone, has issued a circular as President of the Commission in that Settlement, to which is added the following list of suggestions as to the subjects of exhibit. Mr. Griffith asks for further suggestions, and writes:—"The committee trust that the inhabitants of Sierra Leone and its dependencies will use their best endeavours to contribute to the adequate representation of the colony. They desire to point out that exhibitions of this nature are the undoubted means of conveying such information to the world as must create an interest in the Settlement and its products, although the beneficial results may not be immediately apparent."

Suggestions for the Sierra Leone Exhibit.

Class I. Literary and Descriptive.—Ancient and modern maps relating to the Settlement; descriptive works; views or photographs of places or buildings; views or photographs of representative native costumes, &c. (arranged in tribes); newspapers and almanacks (the file for the year, early newspapers, &c.).

Class II. Trade Exports; Raw Material.—Mineral—gold, stones. Animal—skins and hides (ox, leopard, deer, sheep, beaver, goat, monkey, otter), ivory, horn, beeswax, honey. Vegetable (foods)—maize, rice, foonday, ginger, cocoa, cola-nut, coffee, coffee, cassada, sweet potato, yams, pepper, Guinea corn. Oil producing—palm-nut, cocoa-nut, benni-seed, ground-nut, koondee, agousie, castor seed, coprah, &c. Gums—rubber, cachew, gbongbo. Dyes—camwood, mangrove, ginger-rose. Spices—cinnamon, pepper, pimento or ehru, yaray.

Class III. Trade Exports; Manufactured Products. — Oils — palm-oil, nut-oil, cocoa-nut oil, kcondee oil. Foods—arrowroot, farina, foofoo, red pepper. Miscellaneous—country soap, potash or lubee, starch, shea butter, country pots, coolers. Jewellery—gold and silver work. Fibres—cocoa-nut, palm, probo (gpérégún), pine-apple, mat rope, borro-borro, and articles made thereof, such as hammocks, fishing-nets, country cloth, odùn, line, rope, mats, basket work, bowls, calabashes, brooms, sandals, &c. Leather work—sandals, scabbard, amulets (sebehs), girdle, fan (abehbeh).

Class IV. Living Animals, wild, curious, or useful.—Monkeys, parrots, snakes, &c.

Class V. Botanical.—Living plants or dried specimens—ferns, orchids, &c. Medicinal—castor oil, physic nut, egbessie, fever bush, ojuologbo, gbangba.

Class VI. Timber.—For export—teak, African oak, brimstone, conta, &c. Native use—mangroves, iron wood, cork wood, bush rope (ty-ty). Manufactured articles—bird cages, from palm rib, country chairs, sofas, &c.

Class VII. Matters of Interest (curious and useful). —Native weapons, costumes, &c.

Class VIII. Supplies for Fruit and Vegetable Market. Mangoes, pine-apples, bananas, oranges, &c. Preserved fruits.

The Melbourne *Argus* reports :—" Local arrangements in connection with the Colonial and Indian Exhibition are progressing favourably. The exhibits of wine promise to be an important feature of the court of the colony. Over 7,000 gallons, representing over 42,000 bottles, have been entered, and, in addition, a practically unlimited quantity will be available for sale during the Exhibition. His Royal Highness the Prince of Wales having expressed his desire that specimens of Australian fish might be exhibited in the aquarium which will be open in connection with the Exhibition, the trustees of the Melbourne Exhibition building have given the matter their consideration, with a view of determining if specimens of the rarer varieties might not be sent from the Melbourne Aquarium. It has, however, been found that a very great cost would be incurred in sending anything like an adequate supply of fish, and the project has therefore been abandoned. It has been decided, however, to forward for exhibition in the Victorian court upwards of 100 water-colour drawings of the fishes of the colony, which have been executed to the order of the trustees by a competent artist, and which, it is hoped, will be of interest to ichthyologists and others. It is also the intention of the trustees to request the Government to assist them in the production of a descriptive work on Victorian fishes, the illustrations of which will be taken from the plates just mentioned. Professor M'Coy has promised his assistance, and Mr. J. E. Sharrard, the secretary to the trustees, is already engaged in collecting materials for the work."

PATENTS IN 1885.

The *Times* of the 5th inst. contains an article on this subject, relative to the appointment of Sir Farrer Herschell, the Earl of Crawford and Balcarres, and Baron Henry de Worms, M.P., as a committee to inquire into the working of the Patent-office under the Act of 1883.

The following particulars respecting the working of the Act in 1885 are taken from the article:—

On the whole, it need not be doubted that the Act has given satisfaction to inventors. Reduction in fees was what they mainly clamoured for, and this they got, at all events in the initial stages. If the number of patents applied for be taken as a criterion of the value of the Act, there can be no further question about it, for in this respect its success exceeded the most sanguine expectations of its promoters. In the first year of the new Act there were 17,110 applications, not far from three times the number in any previous year, and in the year just past there were 16,101. This falling off of a thousand may easily be accounted for by the fact that there was a sort of accumulation of inventions at the beginning of 1884 waiting for cheap patents, as is shown by the rush to the Patent-office in the earlier months of that year.

It would be satisfactory if the quality of this enormous number of inventions could be as readily tested as their quantity, but this, unfortunately, is not possible. One rough test, indeed, is afforded by the number of applications which are allowed to lapse at their first stage.

The applications made in 1884, and which became void in consequence of the complete specification not having been left within 10 months from the date of application, amounts to 7,013, and the addition of applications voided for other reasons brings the total to 7,064, or 41 per cent. of all the applications made in that year. The average number of applications void from a similar cause under the Act of 1852 (which remained in force till January, 1884), was 35 per cent., and in that case the additional fee for the complete patent was £20. It is a little surprising that the per-centage should be increased, and that a fee of £3 should kill no less than two-fifths of all the applications for patents—that is to say, that the inventors of two-fifths of the inventions for which patents are applied for do not consider them worth £3 a piece nine months after they have attempted to patent them. It used to be said under the former law that it was the heavy fees in the initial stages which killed patents, but this is certainly not now true. On the other hand, it is to be admitted that patents are now taken out for much more trivial inventions than were formerly considered worth the expenditure of the higher fees.

It is some comfort to think that, under the short amending Act above referred to, all the provisional specifications relating to these 7,000 applications will be kept secret, if not destroyed, and no record will, therefore, be preserved of this vast mass of incomplete invention. This salutary provision—which, by the way, was suggested in the Bill brought in in 1883 on behalf of the Society of Arts and was then rejected by the framers of the Act—will not only prevent future inventors having the risk of their perfected inventions being interfered with by an abandoned application, but the owners of the abandoned applications themselves will be able to relinquish their first claims and substitute a fresh application, based on fuller knowledge of their process or their machine. It would appear that one result of this provision might be to enable an inventor, by constantly renewing his application, to work a process, for some time at all events, in secret, while yet having the advantage of protecting it by a patent, which could at any time, if necessary, be completed, thus practically defeating the object of the Patent Act, which is, of course, to insure the publication of information for the general good in return for the limited privilege granted to an inventor.

It might be a question well worth considering whether the destruction of all provisional specifications would not be an advantage. In that case, the examining staff would have to be relied on to see that an inventor did not introduce into his complete specification fresh matter, possibly obtained from a rival.

About 20 per cent. of the total number of applications for patents are from persons not resident in the United Kingdom, and the suspicion cannot but arise that a certain proportion of this large per-centage are applications for patents made with the idea of preventing the working of an invention in this country, and therefore enabling its owners to supply English markets with goods manufactured abroad. Under the Act the Board of Trade have power to compel an inventor to grant licenses. But the *mandamus* by which this provision is to be enforced cannot reach the foreigner, and the Board has no power to cancel the patent. It may be thought that in any case in which there had been failure on these grounds to obtain a license, the fact of having applied for one would be sufficient defence to an action for infringement; but this is one of those questions which remain matter for speculation until the Courts have had their say upon it.

OYSTER AND MUSSEL CULTURE AT LA ROCHELLE.

The coasts of Charente Inférieure abound in a great variety of shell-fish. Their formation consists chiefly of soft mud and sand, with long reaches of calcareous rock, which are especially favourable to the culture of the oyster and mussel. Vice-Consul Hayes Sadler says that though formerly very productive, the natural oyster beds in the Pertuis d'Antioche and the Pertuis Breton became exhausted from constant and indiscriminate dredging, and those which formed from time to time within reach of the coast population, were soon worked to destruction. Consequently, the numerous artificial beds once cared for became gradually neglected, and ten years ago were partially abandoned, from inability to procure the necessary supply of oyster spat. At this time, the Portuguese oyster first made its appearance, and from its prolific character, a fresh industry quickly sprang up, on a large scale, and has proved very remunerative. About the same time, restrictions on the destruction of natural beds were more vigorously enforced, with the object of reviving the culture of the French or native oyster. Some experienced ostreiculturists also, from Arcachon, established at Marennes, and at the Isle d'Oleron. A large number of young oysters are now annually brought from Arcachon to the beds at La Rochelle, where they grow and fatten at a more rapid rate, and the industry has taken a wide extension. Old beds, neglected for years, have been again sought after, and replenished, many new ones made, and almost all available spots on the coast are now occupied by artificial beds, which are rented from the State at about four shillings per acre. The spat is collected on hollow tiles, and the young oysters become fit for market in two years after removal to the beds. The beds of Marennes and the Ile of Oleron alone produced 210,000,000 oysters in 1883, the greater number being Portuguese. The French oyster fetches from two to four pounds per thousand, according to quality, and the Portuguese about ten to twelve shillings per thousand. The two kinds, which are different in their nature, do not thrive well together; the Portuguese from its greater voracity gives the French oyster no chance of flourishing on the same ground, and is, therefore, kept clear from the beds where the culture of the latter is carried on. The green oyster of Marennes has been for time immemorial prized for its delicate flavour, and is peculiar to the Estuary of the Seudre. Along both banks of this river, for some fifteen miles, are large shallow tanks or reservoirs excavated in the flat marshes, and in communication with the sea at high tide by ditches and sluices; here the oysters are placed in the spring of the year, and here alone they gain their peculiar tint. The colour is said to be derived from feeding on a tiny seaweed resembling the green moss on a damp wall, which forms in autumn, covering the surface of the reservoirs and remaining till the following spring, and is greedily devoured by the oysters. A vast number of people gain their livelihood from occupation in these reservoirs, as well as in the artificial beds which line the banks and mouth of the river and other parts of the coast. Hundreds of fishermen and boats are also employed in the daily visits to the oyster beds, in providing the necessary supply of young oysters, or in other duties which the culture entails. Consul Sadler says also that the culture of mussels is a characteristic, and in its extent, an almost peculiar, industry in the neighbourhood of La Rochelle. Mussels abound all along the coast in their natural state, but as such, are ill-conditioned and often poisonous, whereas those brought up in the beds are plump, delicate in flavour, and healthy as food. The culture is carried on in many other parts of the Pertuis, but the chief centre is the Bay of Aiguillon. Commenced by an Irishman as early as the 11th century, at a spot which, from accumulation of deposit having in time altered the outline of the coast, and formed a vast extent of low-lying marshes, is now dry land, this industry has for the last 800 years been carried on in much the same way, but it has greatly developed of recent years. While, forty years ago, there were little over 300 beds in the Bay of Aguillon, there are now 3,000, and they stretch for more than seven miles along the shores of Charron and Marsilly, and if longitudinally joined, would measure 200 miles in length. The aspect of the sea in the bay clearly shows the nature of the bottom it covers, and a vast expanse of mud is exposed at low tide. As the tide ebbs, the beds gradually come to view, and it is then the fishermen start in their small boats to collect the mussels or work in their respective allotments, returning as the tide advances. The beds consist of palisades formed of stakes three yards and a half long, driven half their length into the mud, and placed at equal distances of one yard and interlaced with faggots. Formerly, two lines of palisades were placed at right angles, with the apex turned toward the sea, and the space of one yard left open for an osier basket to be placed for such fish as might be caught on the receding tide. Many of these beds still exist, but the system now is to arrange the palisades in parallel lines at right angles to the coast, each line being 100 metres long, with a distance of about 20 metres between each. There are four rows of these beds, separated by long spaces or streets parallel with the shore. The row of beds nearest the coast is uncovered at every tide, the second is uncovered at neap tides, the third is only left dry at spring tides, and the fourth at equinoctial tides. The latter are not interlaced with faggots. The young mussels are removed from time to tine from the further rows to the one nearest the shore, where the full grown are gathered for market. This is done in pockets of old nets, which are tied to the stakes and soon rot, the mussels attaching themselves to the new bed. Work is continually going on in removing or thinning the young mussels, gathering the full grown, replacing stakes or repairing damages. The flat-bottomed boat, or *acon*, used by the fishermen, is similar to the one used 800 years ago, and is built of three planks, with a piece of wood at right angles to form the stern. The bottom plank is of hard wood, and turned up as a prow. Holding the sides with his hands, and with one knee at the bottom of the boat, the fisherman pushes the boat forward and steers with his other leg, on which he wears a long boot, almost as fast as a horse can trot. The mud disturbed by the sea in winter settles down in the spring in ridges, the tops of which become hard and dry under a hot sun, and renders manœuvring these little boats extremely difficult, as they cannot slide on a dry or uneven surface. It is at this time that myriads of small crustaceans, the *Corophium longicornis*, make their appearance, and in their voracious hunt for the numerous sand worms on which they feed, break up these ridges, and in a very few weeks the surface is as level as it was in the autumn. These little animals disappear almost in one day at the end of October, when they seek the open sea, to return again in April. Formerly, the beds were the property of those who worked them; but, the Government having claimed its shore rights, they are now held under grant from the Government, and in 1872 a rent of 5 centimes per metre was imposed on each *bouchot* or palisade. The produce of the beds in the Bay of Aiguillon amounts annually to between 120,000 and 130,000 hectolitres, or from 330,000 to 350,000 bushels, and the value to between £50,000 and £55,000.

THE ST. GOTHARD RAILWAY.

The reduction in the rates of freight for international traffic between Germany and Italy has had the effect of considerably increasing the goods traffic on the St. Gothard line, notwithstanding the passenger service and carriage of provisions suffered seriously in consequence of the quarantine restrictions ordered by the Italian Government.

The traffic, which during the second half year of 1882 amounted to 53,386 tons from Germany and Belgium to Italy, and 19,442 tons *vice versâ*, was, during the two succeeding years, as follows:—

	1883. Tons.		1884. Tons.
Germany and Belgium to Italy..	204,690	..	210,000
Italy to Germany and Belgium..	37,228	..	39,000

Making a total of 241,918 tons during the former, and 249,000 tons during the latter, being therefore considerably in excess of what had been anticipated for those years, it having been estimated, taking as a basis the amount of goods carried from 1876 to 1878, that the tonnage for the past year would have increased up to 150,000 to 152,000 tons.

The principal goods carried on this line during these two years from Germany to Italy were :—

	1883. Tons.	1884. Tons.
Mining or metallurgical products	103,200	89,958
Coal (exclusive of heat used on the line)	53,328	64,835
Glass and pottery	4,102	6,478
Wheeled vehicles	2,741	6,637
Grain, dairy produce, beer, tobacco, substitutes for coffee. &c.	4,036	5,068
Raw material for agriculture and industry	4,909	5,003
Do. for textile manufactures	2,561	3,412
Do. for paper-making	1,112	1,610

From Italy to Germany the principal goods were :—

Eggs	12,900	13,125
Hemp	3,600	4,476
Marble	1,750	1,962
Fruit	2,288	3,558
Oil	1,477	1,495
Raw cotton	1,163	1,768
Wine	2,626	1,637
Cereals	1,234	316

The traffic of the St. Gothard Railway is capable of considerable extension, but it would be necessary to provide greater accommodation at the port and railway station of Genoa.

HEALTH OF LONDON.

Professor Corfield, the medical officer of health of St. George's, Hanover-square, has presented to the governing body of the district, which includes Belgravia, Mayfair, and the central parish of St. George's, an interesting account of matters relating to health in that part of London. In the completed twelve months under notice, while the death-rate of London as a whole stood at 20·3, and of 28 large towns in England at 21·6 per 1,000 of population, the rate of all St. George's stood at the low figure of 16·30. The low death-rate of St. George's is not only in strong contrast with the rates in other parts of London, but also with some of the large English, Scotch, and Irish towns. Preston, in Lancashire, has the largest death-rate of the English towns, standing at 27·3 per 1,000 of the population, and is closely run by Manchester, with 26·4, which is again closely run by Liverpool with 25·2. Glasgow had a death-rate in 1884 of 26·9, and Dublin 27·5. There were only five towns in England which had a lower death-rate than St. George's, and these were Barrow-in-Furness, Burton-on-Trent, Darlington, Hastings, and Maidstone. The division of St. George's into sub-districts shows that while the death-rate of Mayfair sub-district was as low as 12·44 per 1,000 of population and Hanover-square sub-district 15·54, the Belgravia part ranged as high as 17·40, a sufficient indication that the more crowded district which is included with Belgravia as Pimlico influences the death-rate of the district which has within it the wealthiest part of the metropolis. The birth-rate of the whole district is as low as the death-rate. The average birth-rate of Greater London is 34·9, while in St. George's as a whole it only reaches 21·18—namely, a rate of 16·46 in Hanover-square sub-district, 15·20 in the Mayfair sub-district, and 23·87 in the Belgravia sub-district. Other statistics show that a larger proportion of persons attained an advanced age in the district than in London generally, and this is attributable in some degree to the fact that persons with ample means select this part of London as their residence. The fact of the violent death-rate in St. George's being considerably higher than for the whole of London, is due to the fact that the Serpentine is in the parish, and the deaths which occur in that river are brought to bank in St. George's. The mean duration of life in Mayfair, it may be added, was, in 1884, 72·70; in the Hanover-square sub-district it was 62·92; and in the Belgravia sub-district it was 49·78. In London, as a whole, the mean duration of life, in 1884, was 38·08—a rate which was an improvement upon previous years. The mean duration of life has been increased in this western part of London since 1875 by seven years, and in London generally by nearly four years, since 1879. Regarding preventable infectious diseases, measles, whooping-cough, and diphtheria had been higher than in previous years, while typhus and scarlet fever had been very low; in fact, in regard to typhus, it was doubtful whether the record of a case was not wrongly described as of this dreaded disease. Enteric disease still kept up its numbers, and, therefore, watchful attention was paid to the sanitary arrangements in all parts of the district. The returns of nuisances dealt with by the officers under Dr. Corfield, show the need of constantly watching over the sanitary condition of houses in a part of the metropolis where it might be reasonably supposed the population would be equal to the care of their own health. However, in St. George's west, as in St. George's east and south, houses had to be inspected, drains trapped by order of the officers, cesspools abolished, also by order, animals improperly kept had to be removed, and legal proceedings had to be taken against an owner to compel work to be done in the interests of the public generally, and in the immediate interests of the payers of rent. In all. 619 complaints were made of insanitary nuisances, and in these remedies were made in all, with the exception of eight, in which eight the authorities "could not assist." There had been 146 analyses of articles of food sold in the district made in the twelve months, and of these 87 were genuine, 7 were "doubtful," and 52 were adulterated.—*The Times.*

COCOA-NUT FIBRE.

The following particulars respecting the manufacture of cocoa-nut fibre are taken from an article by Mr. J. R. Jackson in the *Gardeners' Chronicle* :—

Cocoa-nuts, or as they are generally termed in the trade coker-nuts, to distinguish them from the *Theobroma cacao*, which furnishes cocoa and chocolate, are shipped principally from Trinidad, Jamaica, Demerara, Tobago, several of the other Leeward Islands in the British West Indies, Ceylon, Belize, (British Honduras), all round the coast of America, and the Fiji Islands; the quantity landed in the United Kingdom being about 12,000,000 yearly. Nearly all the nuts are imported in the husks or outer covering, from which, on arrival, they are stripped by men using two fine-pointed steel chisels, and who, by constant practice, become so skilful in the art that many are able to open 1,000 to 1,200 per day. The nuts themselves, after being removed from the husks, are generally sold to wholesale fruit dealers, who, in turn, supply the retailers, costermongers, and others, but they are likewise often sold under the hammer at public auction.

After removal from the husk they are sorted into seven sorts of varieties, known respectively as large milky, middle size, small, starters, milky growers, green and dry. Those from Trinidad are the sweetest in flavour, and are mostly preferred by the manufacturing confectioners, biscuit-makers, and others, though the Ceylon nuts run them very close in quality. Cocoa-nuts are largely used in the North and West of England, and they are also in great demand at holiday times, at fairs, on racecourses, and such-like gatherings in all parts of the kingdom. The husks, after the nuts have been cracked, are stacked in the yard in the open air, until they are required for conversion into fibre ; for this purpose they are first passed singly through a powerful "crusher," or "back-breaker," driven by steam-power, with large revolving, corrugated wheels, which flatten the husks, and to a certain extent make them more pliable ; but after this severe pressure, so springy is the natnre of the husk that, somewhat like a sponge, they immediately assume their original shape on emerging from the crusher. They are then thrown into huge stone tanks, each holding many thousands, where they undergo several hours' steaming and soaking. Great care and skill are required to know how long to keep them in the tanks, husks from different countries requiring more or less time according to circumstances, such as age, thickness of outer cuticle, substance of fibre, and other peculiarities known to the manufacturers. In the tanks the husks swell considerably, and have to be kept down by heavy pressure.

After the husks are sufficiently soaked they are ready for the mills, which are technically known as "Teasers" or "Devils," and consist of cylinders or drums, each being studded on the outer circumference with about 3,000 fine or thick 3-inch steel teeth, specially tempered. The mills vary slightly according to certain requirements. They are driven by steam, and revolve with great rapidity, requiring the utmost care and constant attention of the workmen. Each husk is divided longitudinally into thin pieces, and each piece is passed into the mill separately by the workman between two steel rollers, the workman retaining a firm grip of it so as not to allow it to pass out of his hands ; but the few moments he holds it there the drum with its numerous steel teeth is revolving, and combing out the irregular fibre and refuse. After one-half of the slice of husk is thus cleaned the workman reverses it, passing in the other half. The continual feeding of these mills gives such strength of wrist and dexterity to the workmen that what appears a very dangerous operation is gone through with wonderful rapidity, and each slice of husk is passed through three of these mills in succession, occupying but a few seconds from the time that the crude husk is passed into the mill until it comes out a perfectly cleaned bundle of light brown separated fibres ; these bundles are next laid out in drying rooms on heated iron tables to perfectly dry them, when they are ready for making brushes and brooms of various kinds.

It will be seen that the principal attention has been given to the long clean fibres used for brush-making, but there are other processes to which I have not yet alluded. If a cocoa-nut husk is cut through transversely, it will be found that immediately under the outer woody coating the long brush fibres, if we may so call them, are deposited to the thickness of about half-an inch ; nearer the centre, and immediately surrounding the nut, the fibres are more irregular, somewhat matted, and mixed with soft brown refuse. In the process of passing through the mill, and separating the brush fibre, this finer fibre and refuse is thrown out at the back, from whence it is collected and placed on elevators, and carried automatically into the mouths of double rotary screens or "willows," peculiarly made for the purpose, a spindle fitted with arms or rods running the entire length, and after many revolutions and much tossing about, the fibre is separated, and falls out at the lower ends clean and ready to be dried. This fibre is used for matting, and is not only supplied in large quantities for mat-makers, but also to the Government for mat-making in prisons; it is further largely used for stuffing mattresses saddles, &c. The refuse, by a special process, is separated into two different qualities, the ordinary coarse kind being used for general horticultural purposes, and the granulated for conservatory use and potting.

Obituary.

PROFESSOR SHELDON AMOS.—Mr. Sheldon Amos, who died at Ramleh, near Alexandria, on the 3rd inst., aged fifty, was the youngest son of the late Andrew Amos, Professor of Law at Cambridge. He was educated at Clare College, Cambridge, where after gaining the Members' Prize in 1858, he took his degree in the year 1859. On leaving the University he devoted himself to the law, and was called to the Bar as a member of the Inner Temple on the 11th June, 1862, having obtained a certificate of honour in May of the same year. Professor Sheldon Amos occupied for some years the chair of Jurisprudence at University College, London, but he passed many of the later years of his life abroad. After some stay in Australia, he established himself in Cairo, where, on the reorganisation of the criminal administration of the country, subsequent to Lord Dufferin's visit to Egypt, he was appointed English judge of the new native Court of Appeal, which post he occupied at the time of his death. Professor Amos was the author of several legal treatises, and for his work "A Systematic View of the Science of Jurisprudence," the Swiney Prize was awarded in 1884, by a joint committee of the Society of Arts and the Royal College of Physicians

General Notes.

COTTON SEED.—According to experiments by Sacc (*Journ. de Pharm. et Chem.*), cotton seed has the following composition :— Casein, 6 per cent.; dextrin, 2·0; sugar, 2·0; fibrin, 23·7; woody fibre, 32·1; starch, 9·6; greenish-yellow oil, 9·6; yellow wax, 0·8; water, 8·0; ash, 8·0. The seed affords by grinding 56·5 per cent. of a yellow meal, which may be employed with milk in bread-making. This meal, or what is cheaper, the residue left after the seed has been passed through the oil-press, is available for clarifying syrups.

TELEGRAPHS AND TELEPHONES IN GERMANY.—The number of telegraph offices in Germany has nearly doubled during the last four years, during which period 4,415 new ones have been opened, the total number of 5,014 in 1880 having been increased to 9,529 in 1884. The total length of telegraph lines has increased from 121,520 miles to 150,040 miles during the same period, an addition of 28,520 miles. The telephonic service, which was introduced into Germany four years ago, now counts 58 central offices, 7,311 subscribers, and a network of upwards of 10,000 miles. During the last six years considerable progress has been made in the extension of the use of the electric light, and at the present time upwards of 600 dynamos and 20,000 lamps are in use, and the cost of their installation may be estimated at about one million sterling.

MALLEABLE CAST IRON.—Many cast-iron objects when leaving the mould are too hard for being worked. This happens even with the softest grey pig-iron, when the objects are of slight thickness. In this case moulding with rich sand produces as great hardness as chill-moulding. To remedy this disadvantage, the *Bulletin de la Céramique* recommends the subjection of the objects to a process of annealing, which softens the surface. When the objects treated are in grey pig-iron, they are put in cases surrounded with coarse sand, and heated for twenty-four hours with sal-ammoniac and forge-scales in the proportion of one part of the former to twelve of the latter. It will be remarked that this last process is the same which is employed in the manufacture of malleable cast-iron. Only as in this case there is only a very superficial decarburation to be produced, the heating only lasts twenty-four hours while in the preparation of malleable cast-iron the operation lasts seven to nine days.

MEETINGS OF THE SOCIETY.

ORDINARY MEETINGS.

Wednesday evenings, at Eight o'clock :—

THE FOLLOWING DATES HAVE BEEN FIXED.

JANUARY 13.—"Museums for Trade Patterns." By WM. H. ABLETT. OWEN ROBERTS, F.S.A. Vice-President of the Society, will preside.

JANUARY 20.—"Results of Experiments on Mechanical Motors for Tramways made by the Commission at the Antwerp Exhibition." By Captain DOUGLAS GALTON, D.C.L., C.B., F.R.S. Sir FREDERICK ABEL, D.C.L., C.B., F.R.S., Chairman of Council, will preside.

JANUARY 27.—"Machinery in Mines." By HENRY DAVEY. Sir FREDERICK BRAMWELL, F.R.S., will preside.

FEBRUARY 3.—"Artistic Bronze Casting." By GEORGE SIMONDS. Sir PHILIP CUNLIFFE-OWEN, K.C.M.G., C.B., C.I.E., will preside.

DATES TO BE HEREAFTER ANNOUNCED :—

"The Treatment of Sewage." By Dr. C. MEYMOTT TIDY.

"Calculating Machines." By C. V. BOYS.

"Domestic Electric Lighting." By W. H. PREECE, F.R.S.

"The Experiments with Lighthouse Illuminants at the South Foreland." By E. PRICE EDWARDS.

FOREIGN AND COLONIAL SECTION.

Tuesday evenings, at Eight o'clock :—

JANUARY 26.—"The Importance of a National Scheme of Emigration for the best interests of

British Commerce." By ARNOLD WHITE. The Most Hon. the Marquis of LORNE, K.T., will preside.

FEBRUARY 16.—"The Aspect of Affairs in the Interior of South Africa." By Major-General Sir CHARLES WARREN, R.E., G.C.M.G.

MARCH 23.—"The Commercial Progress of New South Wales." By EDWARD COMBES, C.M.G.

March 2; April 13; May 18.

APPLIED CHEMISTRY AND PHYSICS SECTION.

Thursday evenings, at Eight o'clock:—

JANUARY 28.—"Magnetism of Ships and the Mariner's Compass." By WM. BOTTOMLEY, Jun.

FEBRUARY 11.—

FEBRUARY 25.—"Photography and the Spectroscope in their Application to Chemical Analysis." By Professor W. N. HARTLEY, F.R.S.

MARCH 11.—

APRIL 8.—

MAY 13.—"The Scientific Development of the Coal Tar Colour Industry." By Professor R. MELDOLA, F.C.S.

INDIAN SECTION.

Friday evenings, at Eight o'clock:—

JANUARY 22.—"Burma; the Eastern Country and the Race of the Brahmas." By J. GEORGE SCOTT (Shway Yoe). The Hon. Sir ASHLEY EDEN, K.C.S.I., will preside.

FEBRUARY 19.—"Historical and Recent Famines in India." By F. C. DANVERS, F.S.S., Registrar and Superintendent of Records, India-office. J. M. MACLEAN, M.P., will preside.

MARCH 19.—"Experiences on the Afghan Frontier." By WILLIAM SIMPSON. Col. HENRY YULE, C.B., will preside.

April 2; May 7, 21.

The above dates are liable to alteration.

CANTOR LECTURES.

The Second Course will be on "Friction." By Prof. H. S. HELE SHAW.

Lecture I.—January 18.—The Friction of Solids.

Lecture II.—January 25.—The Friction of Fluids.

Lecture III.—February 1.—The Mechanical Applications of Friction.

Lecture IV.—February 8.—The Methods of Reducing Friction.

ADMISSION TO MEETINGS.

Members have the right of attending all the Society's meetings and lectures. Special tickets are required for the Juvenile Lectures. Every member can admit *two* friends to the Ordinary and Sectional Meetings, and *one* friend to the Cantor Lectures. Books of tickets for the purpose have been issued to the members, but admission can also be obtained on the personal introduction of a member.

MEETINGS FOR THE ENSUING WEEK.

MONDAY, JAN. 11...Inventors Institute, 27, Chancery-lane, W.C., 8 p.m. Special discussion on Patent-law, 1883."

Medical, 11, Chandos-street, W., 8½ p.m.

Asiatic, 22, Albemarle-street, W., 4 p.m.

London Institution, Finsbury-circus, E.C., 5 p.m. Mr. Henry Seebohm, "The Migration of Birds."

TUESDAY, JAN. 12...Civil Engineers, 25, Great George-street, S.W., 8 p.m. Mr. F. J. Rowan, "Gas Producers."

Medical and Chirurgical, 53, Berners-street, Oxford-street, W., 8½ p.m.

Photographic, 5A, Pall-mall East, S.W., 8 p.m.

Anthropological, 3, Hanover-square, W., 8 p m. 1. Mr. Bryce Wright, "Exhibition of a Bronze Sword found by the late Capt. Sir William Peel, R.N., at Sandy, Bedfordshire." 2. Mr. G. F. Lawrence, "Exhibition of Flint Implements from the junction of the Thames and Wandle." 3. Dr. R. Munro, "Ancient British Lake Dwellings, and their relation to Analogous Remains in Europe." 4. Mr. A. L. Lewis, "Stone Circles in Cumberland."

Biblical Archæology, 9, Conduit-street, W., 8 p.m. Annual Meeting.

Colonial Institute, St. James's-hall, 69, Regent-street, W., 8 p.m. Mr. J. G. Colmer, "Recent and Prospective Development of Canada."

WEDNESDAY, JAN. 13...SOCIETY OF ARTS, John-street, Adelphi, W C., 8 p.m. Mr. William H. Ablett, "Museums for Trade Patterns."

Geological, Burlington-house, W., 8 p.m. 1. Mr. W. H. Hudleston, "A Recent Section through Walton Common, exposing the London Clay, Bagshot Beds, and Plateau-gravel." 2. Mr. James W. Davis, "Some Fish-remains from the Tertiary Strata of New Zealand."

Graphic, University College, W.C., 8 p.m.

Microscopical, King's College, W.C., 8 p.m. 1. Mr. G. F. Dowdeswell, "The Microbe of Chicken Cholera." 2. Mr. A. W. Bennett, "Fresh Water Algæ of the Lake District." Mr. J. W. Stephenson, "Central and Oblique Light in Resolution."

Royal Literary Fund, 10, John-street, Adelphi, W.C., 3 p.m.

Patent Agents, 55, Chancery-lane, W.C., 7½ p.m. 1. Mr. J. E. Remfry, "Indian Patents." 2. Mr. Ernest de Pass, "The International Convention."

Royal Society of Literature, 4, St. Martin's-place, W.C., 8 p.m.

Obstetrical, 53, Berners-street, 8 p.m.

Civil and Mechanical Engineers, 7, Westminster-chambers, S.W., 7 p.m. General Meeting for the presentation of Accounts.

THURSDAY, JAN. 14...Royal, Burlington-house, W., 4½ p.m.

Antiquaries, Burlington-house, W., 8½ p.m.

London Institution, Finsbury-circus, E.C., 7 p.m. Mr. W. A. Barrett, "Charles Dibdin and his Songs for the Sea, the Stage, and the Concert-room." (Illustrated.)

Mathematical, 22, Albermarle-street, W., 8 p.m.

FRIDAY, JAN. 15...Civil Engineers, 25, Great George-street, S.W., 7½ p.m. (Students' Meeting.) Mr. Rudolph E. von Lengerke, "Graphic Method of Determining the Flow of Water in Pipes."

New Shakspere, University College, W.C., 8 p.m. Mr. Richard G. Moulton, "Character-development in Shakspeare, as illustrated by Macbeth and Henry V."

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FRIDAY, JANUARY 15, 1886.

All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

NOTICES.

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INTERNATIONAL INVENTIONS EXHIBITION DIPLOMA.

With this number of the *Journal* is issued a supplement which gives a reduced facsimile of the diploma which will be presented to those exhibitors who received medals at the International Inventions Exhibition. The diploma was designed by Mr. Thomas Riley, under the instructions of a Committee of the Executive Council of the Exhibition, and it is now being printed by Messrs. Goupil, by means of a new printing process, to which the name of typo-gravure has been given. This is one of the methods by which a printing block, capable of being printed simultaneously with ordinary type, is produced by photographic means from a picture or drawing not necessarily in line or stipple. The reduced copy forming the supplement has been printed from a block prepared by the same method by Messrs. Goupil.

Any member wishing for an additional copy of this engraving can have one on application to the Secretary.

UNION OF INSTITUTIONS.

The following Institution has been received into Union since the last announcement:—

Hull Church Institute, 47, Albany-street, Hull.

COVERS FOR JOURNAL.

For the convenience of members wishing to bind their volumes of the *Journal*, cloth covers will be supplied post-free for 1s. 6d. each, on application to the Secretary.

Proceedings of the Society.

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SIXTH ORDINARY MEETING.

Wednesday, January 13th, 1886; Owen Roberts, M.A., F.S.A., Vice-President of the Society, in the chair.

The following candidates were proposed for election as members of the Society:—

Aldwinckle, Thomas William, 2, East India-avenue, Leadenhall-street, E.C.
Atkins, Alfred, Wanganui, New Zealand.
Beadel, William James, M.P., Springfield Lyons, Chelmsford, Essex, and 97, Gresham-street, E.C.
Bedford, Alfred, Waltham-buildings, Holborn-circus, E.C.
Brindle, Thomas, North-bank, Tunbridge Wells.
Criswick, George Stickland, F.R.A.S., Royal Observatory, Greenwich, S.E.
Grahame, Harry, Wanganui, New Zealand.
Kennedy, Thomas, 11, Old Jewry-chambers, E.C., and 61, Warwick-road, Kensington, S.W.
Kirkwood, W. G., Stowford, Mowbray-road, Upper Norwood, S.E.
Lee, Herbert Cabry, 9, Park-crescent, Portland-place, W., The Brewery, Hill-street, Peckham, S.E.
Lyle, Charles, 37, Mincing-lane, E.C.
Medley, Dudley Julius, B.A., Keble College, Oxford.
Milnes, William Stert, Woodstock, Grove-park, Lee, S.E.
Mumford, William Thomas, 36, Oswald-street, Glasgow.
Pain, William, 8, Adelphi-terrace, W.C.
Porter, Nicholas Ellis, 2, Belgrave-terrace, Lee, S.E., and 101, Leadenhall-street, E.C.
Pownall, Robert, Wanganui, New Zealand.
Richards, James, 9, The Chase, Clapham-common, S.W.
Rosenheim, Herman, Highfield-house, Fitzjohn-avenue, N.W.
Turle, Edward, Wimbledon School, Wimbledon, S.W.
Yglesias, Miguel, 2, Tokenhouse-buildings, E.C.

The following candidates were balloted for and duly elected members of the Society:—

Christmas, Walter, 3, Mowbray-road, Brondesbury, N.W.
Edmunds, Lewis, D.Sc., LL.B., 1, Garden-court, Temple, E.C.
Gilchrist, Percy Carlyle, Palace-chambers, 9, Bridge-street, Westminster, S.W.
McDaniel, J. J., Woodlands, Bandon, co. Cork, Ireland.
Nicole, Henry James, Williams-terrace, Chiswick.
Rockstro, W. S., Elm-court, Babbacombe, Torquay.

Vernon, John, 36, Coleman-street, E.C.
Walker, Edward Lake, 22, Great Cumberland-place, W.

The paper read was—

MUSEUMS OF TRADE PATTERNS AND INDUSTRIAL EXAMPLES.

By William H. Ablett.

The prevailing depression of trade in many leading branches of industry lately has caused the conviction that no steps should be neglected to be taken in any direction that is likely to be the means of giving assistance to manufacturing enterprise and technical skill, and I respectfully desire to direct the attention of those who have done me the honour of attending the present meeting, to the great utility of museums of trade patterns, and industrial examples, in aid of technical education; which, established in continental counties, and found to be of the greatest assistance there to manufacturers, are yet quite overlooked in England.

The general idea of a museum is, that it enshrines the past, and that, as time rolls on, the collection that accumulates ought to show in a very interesting manner the yearly progress of manufacturing and inventive skill. But it is not in that light that it would become most valuable, but in teaching men the practical business of their every-day lives, from which each workman could gain an idea, and perhaps bestow one of his own, which, in turn, would become amplified by another.

A most forcible instance of the suggestive value of designs in models for imitation or inspiration—let us call it by both names—exists in the case of Wedgwood, to whom the Duchess of Portland lent the celebrated Barberini vase, which cost 1,000 guineas, and for which, I believe, both competed when it was offered for sale. I can recollect that in my early childhood most of the common crockery-ware in daily use came to us from Delft, in Holland, and it was of a very inferior description. But, thanks to Wedgwood's labour, and to that of those who have succeeded him, those articles in ordinary use, such as jugs, &c., are now tasteful in shape, partaking of the graceful outlines of the Grecian and Roman examples, while prices are so low that instead of importing we are now large exporters of fictile wares; and this can be traced mainly to the influence of one man upon a particular branch of trade!

As the facts in connection with one's personal experience are perhaps amongst the best arguments that can be used for the recommendation of any scheme, perhaps I may be allowed to explain that shortly after the alteration in the fiscal laws in 1860, being a ribbon manufacturer at Coventry, as English ribbons would not sell and the workmen were standing idle for want of work, I was desirous of making certain kinds of trimmings, and for this purpose told my manager to get together all the old trimming makers he could find, and cause them to bring samples of anything they had previously made, with the view of starting something fresh. Accordingly a number of old patterns were brought, but there was nothing to serve the purpose intended, and the great necessity for the existence of a trade collection of patterns to which manufacturers and others might have access then first struck me; for if I could have shown my weavers a collection of German and French trimmings I could have indicated what I wanted and have struck out something new.

This conviction led me to make a move in endeavouring to originate museums of trade patterns, including raw textile fibres of the different kinds, &c., in this country, and for two years I had an office in Westminster-chambers, London, where I made a large collection of patterns of textile materials, which I offered to present to the Government if they would begin the matter by making the attempt at South Kensington. I broached my scheme to the late Sir Henry Cole, and sent pattern-books to the South Kensington Museum to illustrate the method upon which I proposed to work, which was to have bits of textile materials exhibited in cases around the walls and upon screens with folding leaves, by which an enormous variety could be shown in a comparatively small space, with numbers attached to each, duplicate pieces, with corresponding numbers, to be contained in the pattern books, which could thus be handled and examined when required.

In recommendation of the scheme, the accompanying memorial was presented to the Lord President of the Council on the 25th of March, 1867:—

To the Committee of Council on Education, Science and Art Department, South Kensington.

We, the undersigned merchants, manufacturers, and others, having had a proposition brought before us by Mr. Ablett, for the illustration of collections of patterns produced in the current course of trade and manufacture, desire to express to your Lordships our opinion of the great utilility of exhibiting series of patterns, of foreign and home production, for the information of producers of all classes, whether employers of labour or artisans, not only in the metropolis, but in the great centres of industry in the provinces. And considering that it is the special function of the Department of Science and Art to promote the education of the people, we desire to express a hope that your Lordships will see the propriety, and even necessity, for providing that such illustrations shall be collected and exhibited in the manner best calculated to afford practical information to all who are interested in the art, progress, and manufactures of the United Kingdom, with the view of stimulating an honourable rivalry in those branches in which we are excelled by our foreign competitors, which the opportunity of inspecting better specimens would tend to improve, and thus supply the missing link that is needed to connect the School of Art and Design with practical manufactures, and complete the original plan of the late Prince Consort and the Exhibition Commissioners, "to increase the means of industrial education, and extend the influence of science and art upon productive industry." [Here follow the signatures of fifty of the largest wholesale houses in London.]

Nothing, however, came of this, for the matter was referred to the consideration of the South Kensington authorities, who decided they had not room for such a collection to be formed there.

Since that time I have constantly urged the formation of these museums through the Press, and, when residing in France, have had the mortification of seeing my recommendations translated into the French and Belgian journals and acted upon (the Commercial Museum at Brussels having been founded only in 1882), while they have been neglected in England.

Partial museums have, it is true, been formed, but nothing has ever been carried out in a complete manner in this country. Numerous managers and secretaries have applied to me asking for information how these should be formed, but none, I believe, ever grasped the subject so as to understand the full details of the principle upon which they should be carried out thoroughly.

With increased knowledge and technical education a good deal of our trade depression would disappear; for, instead of being supplanted in markets where we have hitherto been supreme, new productions would start to the front, and a briskness of general business would result in many departments of trade that are now behindhand and languishing, if we were leaders instead of being followers of others, as is now the case in many instances. Elaborate systems must necessarily take time to develop; but the simple one I have indicated would effect an immediate change for good in every manufacturing town throughout the kingdom.

Two years ago, finding that two of the Royal Commissioners on Technical Education—Mr. Swire Smith and Mr. Woodall, M.P.—had spoken of the advantages attending museums of trade patterns abroad to meetings which they have addressed upon their return from the Continent, I sent a copy of a pamphlet I had written many years before, in which I pointed out that the progress then being made in Roubaix in certain dress fabrics was threatening the Bradford trade, and explained to these gentlemen that for years I had been advocating their establishment in this country, and had had the mortification of seeing my recommendations translated into foreign journals and acted upon abroad while but very little was being done in this direction in this country, and Mr. Swire Smith was good enough to send me the following answer:—

Keighley, June 5, 1883.

Dear Sir,—I must apologise for not having earlier acknowledged the receipt of the pamphlet you kindly sent me advocating the establishment of museums of trade patterns.

What strikes me so much about the pamphlet is that, although written so long ago as 1868, it is as clear and fresh and direct to the purpose now as it was then. Every word that you say is important, and in my opinion the adoption of your plan, in the practical and business-like way which you suggest, would very materially influence our manufactured products in the direction of greater taste and attractiveness which you indicate.

Although you have spent so much time and money in urging the British public to look after their highest interests in trade matters, I hope you will not despair now, but go on, as you did fifteen years ago, when allies were fewer and the public even more apathetic. Sound advice, such as you are evidently well qualified to give, is still much wanted, and who so likely to give it as one who spoke so prophetically when the danger of foreign superiority seemed to be further away and less likely to reach us than at present?

Believe me,
Yours very truly,
(Signed) Swire Smith.

To W. H. Ablett, Esq.

When I first began to advocate the adoption of museums of trade patterns, I had not the slightest idea that the plan was acted upon anywhere abroad, the necessity of some such expedient having been forced upon my notice from trade exigency at Coventry, as before mentioned; but since the Report of the Royal Commission on Technical Instruction it seems that the Museum of Textile Fabrics at Mulhouse contains a complete series of patterns used in calico printing from the commencement of the trade in Alsace in 1746, up to the present year. There is a permanent exhibition of historical specimens of ancient textiles in cotton, silk, and wool. The new patterns for each year are fixed up and labelled with the names of the producers, whether they be in France, Germany, England, or elsewhere. These designs are in due course removed in order to make way for newer ones, the older ones being mounted in books and catalogued. Those ranging from the year 1829 to 1858 which are considered worthy of being preserved fill no less than 389 large volumes. The leading manufacturers are convinced of the beneficial influence of this museum upon the principal industry of the district. Some, indeed, went so far as to say that they could not see how trade could prosper without it. It is, they think, a source of inspiration to the designer; it sharpens the wits of the manufacturer, is a constant register of the relative progress of competing countries, and it gives individuals assistance in suggesting the adoption of old or historical styles to current wants.

I have visited every town throughout Great Britain wherein any textile manufacture of importance is carried on, and I unhesitatingly affirm that there is not one in the United Kingdom where the standard of manufacturing skill, invention, and design could not be immeasurably raised by the presence of such an institution in its midst. The main idea of late in imparting technical instruction seems to be through the giving of lectures. I certainly am not disposed to undervalue these, but it is very clear that the teacher cannot go beyond what is already known to some; and what we need are further advances, and fresh fields struck out in actual manufacture, for he can only speak of the facts or conditions of matters up to that standpoint which exists and is common to the most experienced persons in any given branch, and here he stops, and his hearers with him.

But the practical manufacturing hand, be he master, overlooker, or first-class workman, gets a new idea from something he sees in a museum, and he makes an addition to it —strikes out something fresh and causes a new departure,—and it is the practical man, and not the theoretical one, to whom we must look for new inventions, fresh combinations, and general improvements in manufacture. And while many schemes and plans might be suggested for the acquisition of enlarged technical knowledge, nearly all, if not quite all, would take a considerable time to develop; while the system I advocate would enable men to teach themselves at once what they need to aim at, because each could apply to his own circumstances the lessons which might thus be gained. No manufacturing centre can be regarded as completely equipped, so far as its public arrangements in connection with the acquisition of technical knowledge are concerned, till it has acquired its "Kunst Gewerbe," which abound in Germany, and also in Switzerland, at Berne, Zurich, St. Gallen, Bâsle, and Winterthur; there is the "Museum für Kunst und Industrie" at Vienna; and the Landesgewerbehalle at Karlsruhe is one of the finest collections in the world. France has taken up this movement upon a large scale in recent years, although there have long been such establishments in Lyons, St. Etienne, and other places. The Dépôt des Lois, No. 1,284, Chambre des Députés, Session 1879, contains a "Proposition de Loi sur l'organisation des musées d'art industriel," in the Budget of the same year the Chamber voting 1,000,000 fr. for this purpose. "During a recent visit to the Continent," writes Professor Charles U. Yates, of University College, Nottingham, "I paid special attention to these questions, and had frequent conversations with the leading manufacturers in different towns concerning this subject. From Germany, through Austria, Switzerland, France, and Belgium I have only heard one opinion; I was invariably told that the trade museums were not only a great benefit but many men considered them indispensable. Such testimony, combined with the recommendations of our Commission on Technical Education, should open the eyes of our people. Nottingham, above all other places, stands in need of such an institute, and sooner or later we, and other places as well, will be obliged to take some steps in this direction."

Any person seeing an actual pattern or sample before him, would gain more positive instruction at a glance, than many pages of written description would afford, while the opportunity of inspecting the best manufactures that are produced abroad and elsewhere, would enable any short-coming to be detected at once, and allow of existing errors to be rectified through comparison, and consequently be the means of suggesting excellence in manufactures, that would in vain be sought for by any other method; and so form a permanent collection to which masters and workmen alike might have recourse in seasons of difficulty.

Persons with only a superficial knowledge of manufactures, such as would be possessed by an ordinary buyer of goods, who is acquainted with an article in its manufactured and complete state, ready to be handed over to the consumer, but who are, perhaps, ignorant of the various details and stages through which it is necessary for an article to pass, are struck with the great lack of invention and power to stimulate improvements, combined with an awkward unwillingness to depart from old-fashioned methods, that characterise not only the managers of factories, but the masters also in many branches of English manufacture. They often seem to satisfy themselves, as it were, by following the old round of mechanical production, contented to ignore the more fanciful or artistic finish, that it would be the aim of a more highly instructed individual to arrive at.

That Englishmen are inventive no one can deny, and that much ingenuity and mechanical skill is often manifested by entirely uninstructed workmen is equally plain. In every manufacturing town throughout the kingdom there lie scattered about, among the working population, samples or specimens of attempts at something different, either in the shape of new inventions or improvements, that have never had the opportunity of coming under the observation of those who could put them in a trade form, from the simple fact that there is no system by which these methods come under the notice of those most interested, excepting by chance, or at rare intervals. The industrial exhibitions amongst the workmen that have been lately seen, give ample proof of the manufacturing ingenuity of the working population; but such exhibitions can have no beneficial influence upon manufacturing education.

I do not for a moment deny that in some branches of trade we still excel the foreign producer, and those associated with the branches that still retain their supremacy do not believe we are in any danger from foreign competition; but men ask, why should not an Englishman do as well as a Frenchman or Prussian? He has as good hands, eyes, and bodily faculties as the others, say they, and why should he be excelled? So far from denying that an Englishman equals a foreigner in the ordinary gifts of natural aptitude, I am prepared to say that an Englishman will, as a rule, do far more work than a foreigner, and bring a more continuous and indomitable energy to any given task that he may apply himself to; but it is not here that his weakness lies. It is in deficient knowledge of matters of taste and arrangement, and an absence of that quickness of apprehension and fertility of expedient that is only brought into active life by education, and continuously sustained by daily observation.

But what we now want is a more diffused intelligence in the constantly recurring operations of everyday life, by which not only the skill and talent of the workmen may be increased, but the mind of that workman become more enlarged as to the object and application of his work, and its comparative excellence or defects, when placed side by side with other work. Now no system at present exists for thus aiding the workman, except by means of those chance opportunities that are sometimes brought under his notice, in case of failure it may be; but if a museum of trade patterns existed, the germ of a good thought might become perfected, instead of dying away as it often does now, and ideas from other objects would suggest themselves, so as to form a complete whole of what otherwise would have remained undeveloped.

I have constantly heard it asserted that Englishmen have not any taste, and have heard the most ingenious reasons given why this should be so—amongst others, that there is something dull and heavy in our climate which has an oppressive influence on the mind and fancy. I don't believe anything of the sort. I have heard it gravely asserted that French designers who have come over here, and were celebrated as good workmen in their own country, after being in England a short time could do nothing at all, and went back to France, where they once more picked up again their former excellence.

I can account for such instances easily enough, in the absence of taste and artistic skill amongst the people with whom such an one was placed, which took away from the individual all that spirit of honourable emulation, and this is really the unhealthy atmosphere we have to contend against—the foul air of ignorance, and an absence of inventive design, which the plan I advocate would go far to ameliorate.

In the history of manufacturing process, it is quite well known how often men are at a loss for the commonest contrivances to ensure a certain description of work, or result, that are well known and simplified elsewhere; under these conditions such an institution, in the midst of an industrial centre, would become the foster-mother of inventive design —the Alma Mater of the manufacturing districts—the common centres which would attract all the strayed efforts of genius that otherwise would be unable to find a home and lodgment, which would ultimately ripen into new and perfected systems of manufacture that cannot fail to result in the advancement af any district wherein it is placed. New ideas struggling towards the light, invented perhaps by persons who are not quite aware themselves of the advantages, or the future applications, of what they are doing, would be appreciated by perceptive eyes, which would know how to turn such ideas to the best account. In a local exhibition this result would often of necessity ensue; for the inventions of the workman, who in many branches is ignorant of the best applications of an article, requiring judgment or taste in its disposal, would be seen by the manufacturer, to their mutual benefit; as the workman would find a patron for his invention, and the master get a new idea from the artisan.

The plan would have a very wide application, for there is not a single branch of industry throughout the country that would not be considerably benefited by its adoption. Even in purely agricultural districts, amongst labourers, a kind of museum could be formed of objects of rustic ornament and use, that could be made in winter evenings, or when men are doomed to enforced idleness from stress of weather, or from being out of employment, consisting of such things as chairs, tables, and garden seats, made from branches of trees; ornamental stands for holding flower-pots; straw bottle covers used by wine merchants; and such devices as those for suspending flower-pots in little contrivances of crossed hazel sticks to form a kind of basket, in which drooping or trailing plants are grown. The manufacture of even such objects amongst rural populations would not only supplement their earnings to a small extent by their sale, and add to their material comfort, but would also cause them to be gainers in that contentment and peace of mind which arises from habits of industry, and the exercise of a little ingenuity and skill which is productive of satisfaction in all human effort, let a man's condition be never so lowly.

In the mining districts, a museum would be desirable. The classification of the various ores, enlivened by the beautiful stalactites that abound, would form a very interesting collection—to which might be added models of machinery, and of all appliances used in mining. In the sea-port towns, boats, anchors, cordage, sails, models of vessels, and marine engines, might be well represented; and these would become in time depositories of curiosities brought from abroad, though this is the least useful aspect in which to regard the subject, unless we consider the great probability that useful fibres would be attracted amongst other specimens, which would open out new branches of industry. It is surprising what small advances we make in utilising these, of which a great wealth is spread over the vast tracts of the vegetable kingdom in some countries, that might be discovered and put to profitable use. Travellers from abroad would, doubtless, often send specimens to such an institution, and it cannot be doubted but that we should add materially to our resources, and abundance of useful fibres be discovered.

Models of machinery for effecting improvement in any known branch of industry, would often be furnished gratuitously by those persons desirous of effecting sales of them, and collections could be formed at a very trifling expense, after being commenced, throughout the entire kingdom, with the happiest results to the nation at large.

Mere Workmen's Industrial Exhibitions, however worthy of encouragement on certain grounds, can have no abiding influence on routine manufactures, and, on the other hand, the International Exhibitions are considered by many to have outgrown their just proportions, so that some manufacturers now decline to exhibit, and say the effect of these exhibitions has been to educate our continental trade opponents up to our own standard, and especially in machinery. The proper determination and level of these expedients seems to be indicated in the resolving of these efforts into the final and permanent museum of trade patterns, to be established in all manufacturing centres, which will afford an opportunity for the study and observation of the description of manufacture suitable to each district, and furnish an aid to technical education that could not be obtained by any other means; as every clever manufacturing expedient in practical working would here be displayed, and could be taken advantage of; in short, it would be the best descriptive supplement to technical education that it would be possible to devise, and if universally adopted throughout the kingdom, it would serve as a fresh mark, or epoch, in English manufacturing greatness.

It is generally admitted that from our commercial activity England has derived a great share of her wealth and position amongst the nations of the world, and that to manufacture was almost our necessity; it would seem also as if it were the destiny of Great Britain to clothe the teeming millions of the other portions of the world, and receive in exchange the produce of other countries; but according to the expressed opinions of a great number of eminent men, thoroughly well qualified to pass judgment on such matters, there exists at the present time the most imminent danger that England will lose the supremacy she has hitherto maintained over the rest of the world as a manufacturing nation, unless she girds herself up for the industrial race that she has to run in future with other kingdoms, which are now devoting more attention to the peaceful arts than they formerly did, and whose importations are competing with British manufactures even in the home market. In connection with this rivalry, it has been unmistakably shown that our most successful competitors are found in those countries where the best systems of technical education is in use—notably in France, Austria, Prussia, Belgium, Bavaria, and Switzerland—and the necessity that exists for the more efficient education of the masses is the great social problem of the future in this country.

Assistance of the most valuable kind could be afforded to both artisans and manufacturers by their museum of trade patterns, which would give an opportunity to all interested in any particular branch of manufacture to inspect samples of goods made abroad, which would go a long way towards affecting an improvement, as it would be the means of showing, in a distinct and positive manner, where we are excelled by our foreign competitors, and where our own weakness lies. Not only would the eye be educated in matters of taste through this system, but trade knowledge of almost every description could be gathered from this comparatively simple and inexpensive expedient, out of which other advantages would naturally spring, as the plan would serve as a spur to inventive application, and would render such assistance to those provincial towns which might be inclined to adopt the plan, as would speedily raise their standard of manufacturing skill and design. An ignorant workman cannot be supposed to be acquainted with the many beautiful forms and designs that are familiar to the better instructed one, in whose mind graceful objects are associated in his handicraft. Not only would such a collection have its due influence upon taste in a district, but it would positively give commercial information in the line of business a man was engaged in, by which he earned his daily living. He could handle the samples of his trade opponents, acquaint himself with the methods of manufacture pursued in other countries, see for himself how an article was started in a loom, or an object of metal cast; a glance, in short, would reveal what description of goods came against him in the general markets of the world. Thousands of workmen in this country see nothing else but their own productions, and those of their fellows, from one year's end to another.

If a museum of this sort existed in every manufacturing town, not only would workmen have an opportunity of seeing a full collection of all goods in their own line of business, both native and foreign, but they would see specimens of different goods, from which they would obtain ideas and originate new appliances of their own. Of course, the detail and minutiæ of these museums would have to be left to local or municipal management, which in many instances will be sure to differ from one another; but if a plan was arranged by which any working man who had made any invention, or any new pattern, could exhibit it with his name and address attached, such a system would not only arouse the emulative spirit of the working classes, who would be anxious to exhibit, but it would gather together in one focus all the latent intelligence of that district, and masters could find ingenious workmen whom they never otherwise would have discovered, and the workmen find masters who would take up their inventions and carry them out to a perfected and successful issue, that never could have been arrived at, save for the mutual help rendered to one another.

It must be borne in mind, that for many years past, foreign nations have been making strenuous efforts, and sparing no expense and pains to fix some of the industries that have enriched England in their own countries, and in some instances they have succeeded to a remarkable degree. The broad silk trade of the country—that is to say the trade in silks for ladies dresses—is entirely gone, and there are now no dress silks of any consequence manufactured in England, all the wide goods which are used, being sent to us from France, Germany, and Switzerland, respectively; and the importations of foreign manufactured silk goods amount annually to between £10,000,000 and £11,000,000. This branch is in a worse position than it is generally supposed to be in, inasmuch as, according to the Board of Trade returns, there annually appears to be a respectable amount of silk goods exported. But these, for the most part, consist of silks which have been imported into England from abroad, and now resold by wholesale houses to merchants in our colonies, India, &c., and these figure as English silks, because they are sent out by English houses.

The ribbon trade is dying out in Coventry, no lads being now apprenticed to the weaving business as formerly, though the classes of goods mostly in demand of late are of that description which comes best within the compass of what the English manufacturer can do, consisting mostly of "union" goods; for in "all-silk" ribbons there is no competing with the Basle makers in the low-priced descriptions, or those of St. Etienne in the higher classes.

As a counterpoise to this unsatisfactory condition of affairs, it is gratifying to be able to remark that a new branch has recently sprung up in this country in the form of spun and waste silk, in which we have so far beaten the foreigner; but it is impossible to say how long this fortunate condition of affairs may last, for our trade opponents are both numerous and skilful, and soon adapt themselves to altered conditions. But we want more of this inventive spirit displayed which is due more especially to the labours of one individual who has been a successful pioneer in this branch of industry, and the museum of trade patterns would often be found the means of furnishing new suggestions; to meet various contingencies to which we are now exposed, it is plain that we must call up allour labour powers and educate them properly to the general advantage of the commonwealth, and which we have hitherto very much neglected. From the elements within us, the capital and energy of our merchants and traders, the indomitable perseverance and endurance of our artisans, who are naturally industrious and skilful, there is room to build up extended trades in many branches that are now regarded as decaying, or at best stationary.

In the face of the opposition to which many branches of production are at present exposed, it has been often proclaimed that the wages of workmen must be materially reduced. But the proper thing to aim at, I take it, is not to grind down the wages of Englishmen to a continental level, but, by awakening their intelligence, and kindling their emulation, to raise the value of their producing power, which, most assuredly, can be assured; and it is from a deep conviction that this can be done that I have ventured to address you to-night; and my own experience has proved to me that one of the most lasting and surest methods of raising the skill of our workmen is by adopting the method of museums of trade patterns.

The increased use of machinery, which is destined ultimately to do most of the work of men's hands, will, with its increased perfection, bring a disturbing element with it, insomuch that it will be mainly its rapid production in the manufacture of goods, its producing capability as regards quantity, which will compel manufacturers to stop from time to time, and thus unsettle the regular employment of labour, which will be liable to greater fluctuations than have yet been known. Of course, when markets are stocked, production must cease, and the result now referred to is being experienced periodically, to a slight extent, in one or two branches of manufacture.

It is, therefore, to be hoped that the workmen of the future will, with increased intelligence, become, as a body, more thrifty and saving, so that while earning greater wages in times of prosperity, their prudence will cause them to make better provision than is now often practised for intermittent days of adversity when they arrive.

I am firmly convinced that the future prosperity and welfare of this country will very much depend upon the working classes—I mean those who depend upon their daily exertions for the means of living, those who have not private property of their own to subsist upon—and it will be to their advantage to endeavour to get adopted every useful expedient that can be devised for increasing their own efficiency, and the value of their own exertions, for as individuals become richer, the riches of a State also increase proportionately, and it is really imperative, for more reasons than one, that the importance of the plan that I advocate should be widely felt, known, and understood, for it will be found as practically useful to my fellow-countrymen engaged in manufactures as the Sunday-school scheme of Raikes proved to be to religious and secular elementary education. But it is a hard matter to produce an impression upon the British public, unlike the French, who are charmed with an "idea," and enthusiastically carry it out to its practical termination.

Further, it naturally follows that foreign importations which are now conducted upon such a large scale must inevitably displace so much native industry, and, to compete with the foreigner, the Englishman must fall back upon productive skill, or the economising of labour, which can only be effected through a superior intelligence—an inferior one, of course, stands no earthly chance against one who pays less taxes than we do, and can manufacture his goods at a far less cost than that paid for English labour.

Business matters are now so conducted, that those who manage them may be fairly said to be engaged in a race, in which the most skilful will be sure to win. The hidden powers of nature, which are now being subjected to the control of man's increased and ever-growing knowledge, are doing their share in the work of man's daily life, and are creating entirely new combinations of results in every direction.

There appears to be something in the peculiar character of Englishmen, that they never do their best until some strong opposition is brought to bear upon them, when the combative and persevering spirit of the nation seems to be brought out, and great improvement often results after a temporary collapse.

May the opposition we are now experiencing in many departments of trade infuse the old energy into us, and lead us to glorious, yet bloodless, victories on the broad field of honourable competition. Yet viewed in a national point of view, as from that of the stand-point of free trade, if the State makes laws which permit manufactured goods to come into England duty free, it would be some slight concession and assistance if the Government were to inform those manufacturers of the country who have been the hardest hit by this arrangement, what goods come against their own in the markets of the world, which could be done effectually through the instrumentality of these museums. And I would therefore suggest, in conclusion, that one should be established in London to serve as a model, and assist provincial towns desirous of establishing a museum of trade patterns of their own, which of necessity would be very varied in their aims and methods of management. To the parent museum our consuls might furnish information and samples of goods that are either produced or wanted abroad, together with any details of an useful character which might afterwards be disseminated in the various producing centres of the country which they would mostly concern. Such a museum could be begun at a comparatively trifling expense, and would gradually attain to very considerable proportions. A large amount of valuable specimens could be obtained gratuitously from persons desirous of aiding the scheme, which would be found to accumulate rapidly, and form a most valuable aid to the development of technical education and business knowledge of every description. I may add that the proposed plan has met with the approval of a few close observers of the rapid progress made by other countries in technical knowledge, and having about three months since written a couple of letters on the subject in the *Manchester Guardian*, amongst other communications I received the following from Mr. Thomas Wardle, one of the Assistant Commissioners who prepared the admirable report on the silk industry for the Commission on Technical Education :—

St. Edward-street, Leek.
Sept. 5th, 1885.

Dear Sir,—I have just seen your excellent letter of August 26th, in the *Manchester Guardian*. I fully agree with you on the importance of trade patterns in local and other museums. Without knowing of your advocacy, I strongly recommended the same idea in my report on the Silk Industry to the Royal Commissio on Technical Education, vol. 3.

Yours truly,
THOMAS WARDLE.

P.S.—I think it an admirable plan to keep us fully informed of foreign competition.

DISCUSSION.

Mr. GEORGE WALLIS said he had hoped that Mr. Ablett would have made progress by this time with the idea which he well remembered talking over with Sir Henry Cole when it was first submitted in 1862-3, and he believed he made a report upon it. If he recollected rightly, the matter ended in the suggestion that if Mr. Ablett could get up a feeling in favour of such a museum on the part of the public, the Science and Art Department would be inclined to take it up. But even at that time, he had had a good deal of experience with manufacturers, and he felt that trade jealousy stood fearfully in the way of anything of the kind; in fact, it was a great stumbling block in the way of the Great Exhibition of 1851. He addressed some hundred audiences in different parts of the kingdom in anticipation of that Exhibition, and his greatest difficulty always was to convince manufacturers that it was to their interest to show what was doing, and by stimulating each other to endeavour to improve the manufactures of the country. This trade jealousy still existed, and would stand in the way of carrying out this idea to a satisfactory conclusion. He always found when an effort was made to establish a local museum, that the general feeling was one of indifference towards what was being done in the neighbourhood; and the only object was to get objects of art, especially pictures. This pictorial craze stood more in the way of real artistic advance than almost anything else. It required almost a surgical operation to get it out of an Englishman's head that all art began and ended with pictures. No doubt it would be a great thing for manufacturers to agree to exhibit a series of their productions, for they would certainly be helping to educate each other. At the time of the Paris Exhibition, in 1867, an eminent French designer, who had retired from business, wrote to South Kensington to say that he had a very extensive collection of designs which he had made and collected for various purposes, and he thought it very desirable that it should go to South Kensington. After talking the matter over with Sir Henry (then Mr.) Cole, some one was sent to report upon the collection, which was about sixty miles from Paris, and ultimately arrangements were made for it to be sent to England on approval. It was there carefully examined, and finally Mr. Cole said they had better get Mr. So-and-So's opinion, mentioning an eminent calico printer and Member of Parliament. That gentleman came and inspected the collection, and gave it as his opinion that they had better have nothing to do with it, adding, that if the purchase were made, he should certainly bring the matter before Parliament. The question was thus settled in the negative, but he had no hesitation in saying that it was simply trade jealousy which actuated the gentleman referred to. This sort of thing was what he had experienced in connection with schools of design. If manufacturers could get designs they could keep to themselves, they would have patronised schools of design much more liberally. There was a favourite quotation, "Sweet are the uses of adversity," and if as a result of the present state of things these petty feelings were overcome, and trade collections established, a great deal of usefnl information would be obtained. For some years it had appeared very doubtful to him whether English manufacturers were making the use they might of all the riches of design at South Kensington, but he found that the Germans and French were constantly sending over their designers to London to study and make sketches in the museums, using those sketches for the purpose of designing patterns, and then sending them to England; and he had seen designs thus originated copied by English manufacturers, because they had come from the Continent. Happily this state of things had much altered, and English designers now made considerable use of the Museum, though they were still always particularly anxious to conceal where they came from, what they wanted to do, and especially that they got their ideas from South Kensington.

Mr. Carpmael said he could echo a great deal of what had just been said. Many manufacturers spent hundreds, perhaps thousands of pounds a year in producing patterns, and the last thing they would desire would be to exhibit such patterns for the benefit of their competitors; though they might not object to their being shown four or five years afterwards, when the fashion had changed. A great deal might, no doubt, be done in the way of preserving good patterns from being lost, but all patterns were not good; the majority were mere rubbish. Mr. Ablett had told them that the collection of a few years amounted to 450 volumes; he thought anyone who had to search through such a mass, most of which was unsuitable for his purpose, would soon get tired and disgusted. If some plan could be devised of selecting what were really worth keeping, and storing them in museums, local or otherwise, great good might be done; but he did not see any possibility of establishing such a museum in London. The magnitude would be too great, if it were to include all manufactures, and the cost would be enormous, both in establishing it and keeping it up. Anything of the kind, to be of real use, should be placed in the local centre of each manufacture, and should contain only selected specimens of the best patterns produced from year to year.

Mr. H. Trueman Wood remarked that it seemed to have been overlooked that there already existed in London a very extensive museum of trade patterns; most of the patterns invented were registered in the office of the Registrar of Designs, in Chancery-lane, and could be inspected by the public on payment of a fee of 1s. for each design. Now the specification of any patent could be seen in the Patent-office library for nothing, and he did not see why the same facility should not be given for the inspection of designs. If that could be done, there would be a very complete museum of trade patterns without any more trouble. A great deal of what Mr. Ablett had said referred to the general question of technical education and industrial museums, and if something in the nature of an industrial museum could be established in London or the great centres, he thought it would be much more useful than a mere collection of patterns. Perhaps the Chairman could inform them whether the City Guilds purposed doing anything of the sort in connection with their fine buildings at South Kensington—a museum which should contain not only selected patterns, but also specimens of the war material of our industries. As to the capacities of Englishmen for design, he would remind the meeting that recent Exhibitions had shown pretty plainly that Englishmen were ahead of any other nation. There was no doubt that in the last Paris Exhibition, the art workers of other countries were anxious to copy the designs of English manufacturers, but that our manufacturers found little to imitate. He had heard the complaint made over and over again that our designs were imitated in an inferior manner. Not long ago the complaint was that goods of inferior quality competed with English articles, but now the complaint was that our makers of artistic wares were being undersold by inferior imitators of their patterns. This complaint had been made to him by five or six of the largest manufacturers of pottery, and also of textiles. Of course the real obstacle to the establishment of a museum of trade patterns was, as Mr. Wallis had pointed out, trade jealousy, but this difficulty might be got over if the patterns were not exhibited until they had been some time in use. One advantage would be, there would not be such an immense number of patterns invented. He believed the number of really good patterns was limited, and if people would only reproduce old ones which were good, and give over the craze for continually producing something new and hideous, it would be a great advantage.

Mr. LIGGINS had been struck by the fact that, judging by the paper they had heard, not a single manufacturer appeared to have given the scheme his approval. The names appended to the memorial were, he understood, all those of London houses who were sellers of articles which other men spent their money, energy, and skill in producing. One of the cleverest pieces of work ever designed and carried out by an Englishman was the yacht *America*, which though built in New York, was designed by an Englishman. The yacht, after she had won the cup, was purchased by an Irish nobleman, and being much decayed, a friend of his was employed to repair or rebuild her; but this was done in the quietest possible manner, one rotten timber at a time being taken out and replaced, and the work was done as much as possible at night, so that the lines might not be copied. This sort of thing was very common, so that he did not think a museum of ship models would be of much use in seaport towns; no trustworthy models would be obtained. You could easily get a model of a large Cunard steamer; but there was scarcely any naval architecture about those vessels—they were merely girders sharpened at each end. It was not a very pleasant thing when we went on board French and German steamers to find that the engines had been copied from English patterns, because they had been in the Paris Exhibition some years ago. On Lake Thun he remarked that the engines of the steamers were exactly Penn's pattern, but the captain said they were made in Belgium. On another occasion he had seen English cotton spinning machinery going to Switzerland, where it was copied, and so England lost the supremacy which up to 1851 she had maintained in all such matters. Formerly he had seen two or three locomotives a week shipped to New York, but the Americans now copied them themselves. He could not agree to all Mr. Wallis said, for he thought it was quite right if a man got a good design that he should keep it to himself. He once had to make a design for a chess-board he was making, and he went to the British Museum where he found a frieze, which when reduced in size answered admirably as a border, but he did not tell all his friends where he got it from. Any intelligent man who wanted a design could always find one in an old book or a museum.

Mr. MILLIS thought there was a decided objection to a museum of trade patterns, but something could be done in the way of industrial museums which would show the principles and methods of working in different industries. He was now engaged in trying to form an industrial museum on a small scale in connection with the Finsbury College, which should be of use to all workers in sheet metal. He proposed to get samples of all metals, ores, and alloys, and also to have a series of examples showing the different kinds of joints most applicable to these various metals. In addition to this he intended to get copies of the best handworking tools at present to be found. A great deal of the excellence of hand work depended on the form of the tools, and though two might appear very similar when put side by side, even in so simple a tool as a hammer, the correct curve in the handle would make a great difference in the work to be done with it. Similarly, shears used for cutting sheet metal by hand were almost becoming extinct, so that in London, to-day, you would hardly find twenty pairs of good cutting shears. An old workman who knew the value of a good tool would give double the price for an old pair of shears to what he would for those now made; though perhaps an apprentice would hardly know the difference. A good collection of tools would be very useful in many trades, and much space would not be necessary for this purpose, nor much expense. He did not intend to show any manufactured articles or patterns of work, but rather the principles underlying the manufacture of all. This would economise space, and be of great service from an educational point of view. In the back numbers of the *Ironmonger* would be found a deal of correspondence as to the reason why American axes had superseded English in the colonies, and it came simply to this, that the Americans had considered the purpose in view, and the colonial backwoodsman, when he had an American axe, felt that he had something best suited to the work he had in hand.

Mr. BARBER desired to endorse what Mr. Millis had said; and would like to see a trade museum established from an artistic point of view. He had sometimes been asked to make things in a certain style, but he had never been properly trained to do so, and he doubted whether there was a man, however good a workman, who could do so. If you told him you wanted something in a particular style, he knew nothing about that style. If a trade museum were formed, you should have in it the best specimens of art of various kinds, not necessarily confined to ancient things, though they were worthy of all admiration, but the best of each year should be selected and exhibited, and then manufactures would gradually improve. With regard to tools he thought the manufacturers made them simply to sell, and knew very little about their use.

The CHAIRMAN said Mr. Ablett called on him many years ago in the City, and propounded this scheme for the establishment of a museum of trade patterns, especially in connection with textile fabrics, and being Clerk to the Clothworkers' Company, and anxious to make that institution useful to the trade with which it was titularly connected, he naturally took a great interest in the subject. From time to time Mr. Ablett had recurred to the subject, but he confessed he had always attached most value to the idea in connection with technical education, with which he had a great deal to do. He knew the jealousy of trade, and it was a very natural feeling in human nature that those who had been at the pains and expense of elaborating some new idea should, at all events, obtain the first-fruits of their labour, before making it the common property of the community. He did, however, desire to see in every technical school, such as were now rising in the various great centres of industry, as a necessary adjunct, a trade or industrial museum. There must be some reference to trade patterns, certainly of the past, because the student ought to know what to avoid, as well as what to imitate. He did not know what the industrial pattern museums at Roubaix and St. Etienne were, but probably they contained mostly English patterns, and he thought it doubtful whether the local manufacturers exhibited their own latest designs. But there was no reason why we should not have the very last information as to the tendencies of patterns, and the direction in which trade instincts were developing. It must not be forgotten that, though there were abstract ideas of design which were very admirable, this was a perverse world, which did not always recognise the virtues of the best design; the tradesman had to cater for his customers, and if the public mind was not educated, he must wait until it was. It would not do for him to be too much ahead of those he had to manufacture for. A trade museum should have not only its academical but its trade side also, and take designs from the tradesman's point of view as well as the art teachers'. With regard to establishing such a museum in connection with the Technological Institute in the Exhibition-road, something had already been done. The Clothworkers' Company had, through Mr. Beaumont, Professor of Textile Industries at the Yorkshire College, presented to the Institute a collection of patterns indicating the raw materials, and likewise the best examples of the manufactured products of wool. It was said to be the best thing extant of the sort, and was finished a few months ago. It must not be allowed to get out of date, so that it would have to be perpetually added to, to keep it up to the mark. In that spirit he hoped these industrial museums, wherever established, would be kept up. He was pleased to hear, not for the first time, of Mr. Millis's laudable attempts in connection with a museum for his own metal-work department at Finsbury College, and hoped that in other departments, besides that presided over by Mr. Millis, similar attempts would be made. He was not aware that any such museums as had been referred to were established in Paris, and he doubted if it would be desirable to attempt such a thing in London. It would be a work of almost insuperable difficulty. and if established he did not think London would be quite the most useful place for them. All these discussions brought forward very prominently the great industrial battle which had to be fought in the present generation. Technical education and the establishment of these museums were all part of the necessary equipment for the industrial combat, which was keener now than it had ever been, and it would become keener still, and the problem was also connected with the question of wages, hours of labour, and many other things which complicated the problem indefinitely. He hoped everyone would do their best to help the country, of which they were all proud to be citizens, to make the battle end in a manner creditable to the public spirit and private energy of Englishmen, and that his old friend Mr. Ablett would get credit for the admirable and enlightened proposals he had brought forward, if they were not all carried out in his time and generation.

Mr. ABLETT, in reply, said he quite agreed with Mr. Wallis as to the opposition of the manufacturers. They were anxious to keep their patterns secret, and felt that if a museum of trade patterns were established, everybody would be educated up to the same level. But that was a very narrow-minded objection, and he thought a groundless one, for he believed the best men would still remain the best, though the standard of design might be raised throughout a whole district. Sometime ago he went to Manchester to endeavour to start a trade museum there, and received a certain amount of support; the late Bishop of Manchester took it up, the ex-Mayor, Mr. Abel Heywood, and others, but when he went to the manufacturers they did not take the scheme up, but rather put a damper upon it. He had been working at the matter for so many years that he was thoroughly acquainted with all the obstacles to be encountered. With regard to what Mr. Wallis had said as to English patterns being copied abroad, he could go further than that, for he knew cases where goods made in Nottingham were sent to Paris, and bought there by the buyer of a large London house, and sold in England as foreign goods. He did not see that the museum of patterns would expose manufacturers to loss, because, wherever a new pattern took the public fancy it would be imitated immediately, unless it were registered, and that was but very little protection. Mr. Millis and Mr. Barber had exactly caught his idea in endeavouring to establish an exhibition of the best tools and appliances in any given branch of trade. Mr. Liggins had shown the value of a museum of patterns, by going to the museum to get a pattern for his chess-board. When people said they did not want to instruct the foreigner, he replied that, unfortunately, the foreigner was instructed, and he complained that the Englishman was not instructed. What he would recommend was to have certain pattern of certain things, so that each trade might see what it was interested in, but the leading manufacturers would not stir out of their way to found these museums, on account of trade jealousy; but if those engaged in any particular trade saw a full collection of their own goods, they could not go away without getting some fresh ideas which would be a benefit to themselves, and also to the country at large.

The CHAIRMAN then moved a vote of thanks to Mr. Ablett, which was carried unanimously.

Notes on Books.

THE YEAR BOOK OF PHOTOGRAPHY, 1886. Edited by Thomas Bolas.

This photographic annual contains the usual amount of information about the progress of photography during the past year, and is also full of receipts, suggestions, and miscellaneous information likely to be valuable to photographers. It is illustrated by a number of blocks made by the various new processes, so much advance in which has been made within the last two or three years. Amongst these is a specimen of Sprague's ink-photo process, which was first brought before the public at the Photographic Exhibition of the Society of Arts in 1881. This is a photo-lithographic process, and prints by its means cannot, therefore, be introduced amongst type. There is also a specimen of a print produced by the stannotype method. This is an modification of the well-known Woodburytype process, by which the mould for producing the pictures is made in a cheaper and more expeditious manner than the metal block used for Woodburytype. In the text we are also given prints from surface blocks by Meisenbach and others. Some of these, it must be admitted, show the difficulty of getting satisfactory prints from blocks having such very low relief in the ordinary process of commercial printing. One specimen illustrates a process by Mr. Borland, by the use of which a printing block can be produced direct from the original negative obtained from the object itself.

MEETINGS OF THE SOCIETY.

ORDINARY MEETINGS.

Wednesday evenings, at Eight o'clock:—

THE FOLLOWING DATES HAVE BEEN FIXED.

JANUARY 20.—"Results of Experiments on Mechanical Motors for Tramways made by the Commission at the Antwerp Exhibition." By Captain DOUGLAS GALTON, D.C.L., C.B., F.R.S. W. ANDERSON, M.Inst.C.E., Member of Council, will preside.

JANUARY 27.—"Machinery in Mines." By HENRY DAVEY. Sir FREDERICK BRAMWELL, F.R.S., will preside.

FEBRUARY 3.—"Artistic Bronze Casting." By GEORGE SIMONDS. Sir PHILIP CUNLIFFE-OWEN, K.C.M.G., C.B., C.I.E., will preside.

DATES TO BE HEREAFTER ANNOUNCED:—

"The Treatment of Sewage." By Dr. C. MEYMOTT TIDY.

"Calculating Machines." By C. V. BOYS.

"Domestic Electric Lighting." By W. H. PREECE, F.R.S.

"The Experiments with Lighthouse Illuminants at the South Foreland." By E. PRICE EDWARDS.

FOREIGN AND COLONIAL SECTION.

Tuesday evenings, at Eight o'clock:—

JANUARY 26.—"The Importance of a National Scheme of Emigration for the best interests of British Commerce." By ARNOLD WHITE. The Most Hon. the Marquis of LORNE, K.T., will preside.

FEBRUARY 16.—"The Aspect of Affairs in the Interior of South Africa." By Major-General Sir CHARLES WARREN, R.E., G.C.M.G.

MARCH 23.—"The Commercial Progress of New South Wales." By EDWARD COMBES, C.M.G.

March 2; April 13; May 18.

APPLIED CHEMISTRY AND PHYSICS SECTION.

Thursday evenings, at Eight o'clock:—

JANUARY 28.—"Magnetism of Ships and the Mariner's Compass." By WM. BOTTOMLEY, Jun.

FEBRUARY 11.—

FEBRUARY 25.—"Photography and the Spectroscope in their Application to Chemical Analysis." By Professor W. N. HARTLEY, F.R.S.

MARCH 11.—

APRIL 8.—

MAY 13.—"The Scientific Development of the Coal Tar Colour Industry." By Professor R. MELDOLA, F.C.S.

INDIAN SECTION.

Friday evenings, at Eight o'clock:—

JANUARY 22.—"Burma; the Eastern Country and the Race of the Brahmas." By J. GEORGE SCOTT (Shway Yoe). The Hon. Sir ASHLEY EDEN, K.C.S.I., will preside.

FEBRUARY 19.—"Historical and Recent Famines in India." By F. C. DANVERS, F.S.S., Registrar and Superintendent of Records, India-office. J. M. MACLEAN, M.P., will preside.

MARCH 19.—"Experiences on the Afghan Frontier." By WILLIAM SIMPSON. Col. HENRY YULE, C.B., will preside.

April 2; May 7, 21.

The above dates are liable to alteration.

CANTOR LECTURES.

The Second Course will be on "Friction." By Prof. H. S. HELE SHAW.

Lecture I.—January 18.—The Friction of Solids.

Lecture II.—January 25.—The Friction of Fluids.

Lecture III.—February 1.—The Mechanical Applications of Friction.

Lecture IV.—February 8.—The Methods of Reducing Friction.

MEETINGS FOR THE ENSUING WEEK.

MONDAY, JAN. 18...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. (Cantor Lectures.) Prof. H. S. Hele Shaw, "Friction." (Lecture I.)

Geographical, University of London, Burlington-gardens, W., 8½ p.m. Mr. J. G. Scott, "The Hill Slopes of Tongking."

British Architects, 9, Conduit-street, W., 8 p.m.

Medical, 11, Chandos-street, W., 8½ p.m.

Victoria Institute, 7, Adelphi-terrace, W.C., 8 p.m. Rev. T. Powell, "The Samoan Traditions of the Creation and the Deluge."

London Institution, Finsbury-circus, E.C., 5 p.m. Rev. Stopford A. Brooke, "The Charm of Venice."

TUESDAY, JAN. 19...Royal Institution, Albemarle-street, W., 3 p.m. Prof. R. S. Ball, "The Astronomical Theory of the Great Ice Age." (Lecture I.)

Civil Engineers, 25, Great George-street, S.W., 8 p.m. 1. Discussion on Mr. Fred. Jno. Rowan's paper, "Gas Producers." 2. Mr. C. E. Stromeyer, "The Injurious Effect of a Blue Heat on and Steel Iron."

Statistical, School of Mines, Jermyn-street, S.W., 7¾ p.m. Dr. Robert Giffen, "Further Notes on the Progress of the Working Classes in the last Half Century."

Pathological, 53, Berners-street, Oxford-street, W., 8½ p.m.

Zoological, 11, Hanover-square, W., 8½ p.m. 1. Mr. H. J. Elwes, "The Butterflies of the Genus *Parnassius*." 2. Rev. T. R. R. Stebbing, "Some new Exotic Amphipoda from Singapore and New Zealand." 3. Mr. Oldfield Thomas, "List of the Mammals of the Hume Collection." 4. The Rev. Canon Tristram, "An apparently new Species of Duck *(Dafila)* from the Central Pacific."

WEDNESDAY, JAN. 20...SOCIETY OF ARTS, John-street, Adelphi, W C., 8 p.m. Captain Douglas Galton, "Results of Experiments on Mechanical Motors for Tramways made by the Commission at the Antwerp Exhibition."

Meteorological, 25, Great George-street, S.W., 7 p.m. Annual Meeting.

Entomological, 11, Chandos-street, W., 7 p.m. Annual Meeting.

Archæological Association, 32, Sackville-street, W., 8 p.m. 1. Mr. H. Syer Cuming, "The Old Traders' Signs in Westminster Hall." 2. Rev. Canon Ayles, "Notes by the late Rev. D. M. Haigh on Barnack Church."

THURSDAY, JAN. 21...Royal, Burlington-house, W., 4½ p.m.

Antiquaries, Burlington-house, W., 8½ p.m.

Linnean, Burlington-house, W., 8 p.m. 1. Dr. Maxwell Masters, "Notes on the Coniferæ." 2. Prof. Cobbold, "*Strongylus Axei* and its Affinities." 3. Mr. J. Starkie Gardner, "Fossil Plants from Mull."

Chemical, Burlington-house, W. 8 p.m. 1. Mr. Thomas Turner, "The Influence of Silicon on the Properties of Cast-iron." (Part III.) 2. Mr. Adrian J. Brown, "The Chemical Action of Pure Cultivations of Bacterium Aceti." 3. Dr. G. H. Bailey, "The Separation and Estimation of Zirconium;" and 4. "Notes on the Analysis of Koppite." 5. Mr. E. Stallard, "The Mono-Cromophthalic Acids." 6. Dr. Divers and Mr. T. Shimidzu, "Mercury Sulphites and the Constitution of Sulphites." 7. Dr. W. H. Perkin, jun., and Mr. A. Calman, "Benzoylacetic Acid and some of its derivatives."

London Institution, Finsbury-circus, E.C., 7 p.m. Prof. J. Perry, "The Distribution of Electric Power."

Society for the Encouragement of Fine Arts, 9, Conduit-street, W., 8 p m. Conversazione at the Galleries of the Royal Institute of Painters in Oil Colours, Piccadilly, W.

Royal Institution, Albemarle-street, W., 3 p.m. Prof. R. S. Ball, "The Astronomical Theory of the Great Ice Agè." (Lecture II.)

Historical, 11, Chandos-street, W. 8 p.m.

Numismatic, 4, St. Martin's-place, W.C., 7 p.m.

FRIDAY, JAN. 22...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. (Indian Section.) Mr. J. George Scott (Shway Yoe), "Burma; the Eastern Country and the Race of the Brahmas."

United Service Institute, Whitehall-yard, 3 p.m. Capt. R. H. Armit, "Machine Guns—their use and abuse."

Royal Institution, Albemarle-street, 8 p.m. Weekly Meeting. 9 p.m. Prof. Tyndall, "Thomas Young and the Wave Theory."

Philological, University College, W.C., 8 p.m. Dr. J A. H. Murray, a Dictionary Evening.

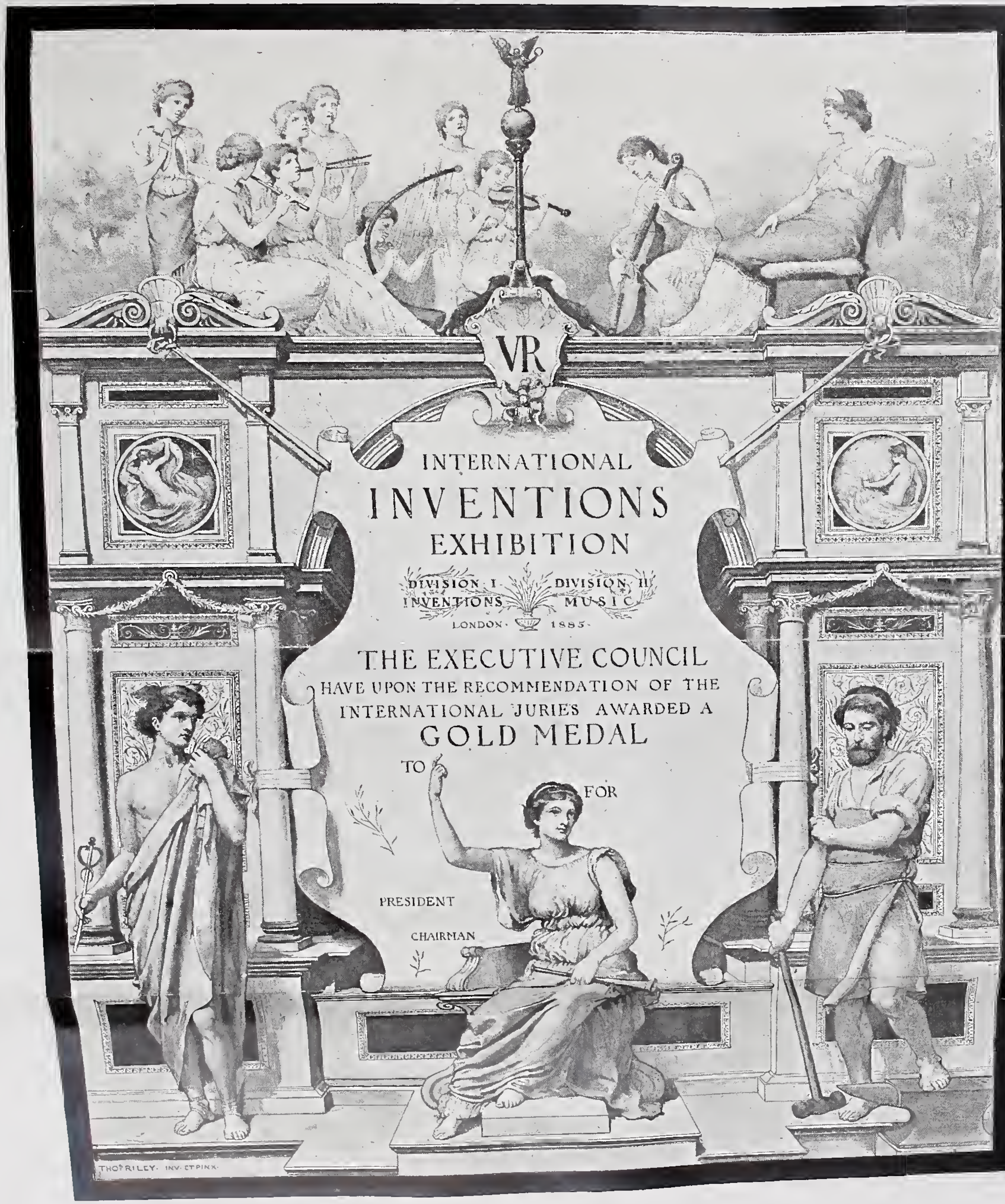
Quekett Microscopical Club, University College, W.C., 8 p.m. Paper by Mr. E. M. Nelson and Mr. Prissi.

Clinical, 53, Berners-street, W., 8½ p.m.

SATURDAY, JAN. 23...Physical Science Schools, South Kensington, S.W., 3 p.m. 1. Prof. W. E. Ayrton and Prof. John Perry, "Note on the paper by Prof W. Ramsay and Dr. S. Young on some Thermodynamical Relations." 2. Mr. A. W. Clayden, "Note on the paper by Mr. J. W. Clark on the Determination of the Heat Capacity of a Thermometer."

Botanic, Inner Circle, Regent's-park, N.W., 3¾ p.m.

Royal Institution, Albemarle-street, W., 3 p.m. Prof. R. S. Ball, "The Astronomical Theory of the Great Ice Age." (Lecture III.)



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INTERNATIONAL
INVENTIONS
EXHIBITION

DIVISION I. INVENTIONS
DIVISION II. MUSIC
LONDON. 1885.

THE EXECUTIVE COUNCIL
HAVE UPON THE RECOMMENDATION OF THE
INTERNATIONAL JURIES AWARDED A
GOLD MEDAL

TO

FOR

PRESIDENT

CHAIRMAN

THOS RILEY. INV. ET PINX.

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Journal of the Society of Arts.

No. 1,731. Vol. XXXVI.

FRIDAY, JANUARY 22, 1886.

All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

NOTICES.

CANTOR LECTURES.

Professor H. S. Hele Shaw delivered the first of his course of Lectures on "Friction," on Monday evening, 18th inst., the special subject of the lecture being the friction of solids.

The lectures will be printed in the *Journal* during the summer recess.

Proceedings of the Society.

SEVENTH ORDINARY MEETING.

Wednesday, January 20th, 1886; William Anderson, M.Inst.C.E., Member of the Council, in the chair.

The following candidates were proposed for election as members of the Society:—

Armstrong, Walter Young, Engineers' Offices, Great Western Railway, Paddington, W.
Catterson, Samuel Prince, 34, Great Dover street, S.E.
Evans, John Luther, 2, Tichborne-street, Edgware-road, W.
Parken, Augustus Henry, Astney-lodge, Bournemouth.

The following candidates were balloted for and duly elected members of the Society:—

Acland, Alfred Dyke, 38, Pont-street, S.W.
Adams, Captain Robert C., care of Messrs. Radcliffe and Brown, 3, Chapel-street, Liverpool.
Bone, William John, 61, Linskill-terrace, North Shields.
Butcher, James, High-road, Gunnersbury, W., and National Liberal Club, S.W.
Creese, Edward James Edgell, Roman-villas, Cirencester.
Innes, Charles A., M.D., 21, Montague-street, Russell square, W.C.
Manuel, George Watson, Fernbank, Catford-hill, S.E.
Morgan, Edward Vaughan, Battersea Works, S.W.
Pearce, William, Leadenhall-buildings, Leadenhall-street, E.C.
Pirrie, W. J., Queen's Island, Belfast.
Varley, Fleetwood E., 2, Vernon-chambers, Southampton-row, W.C.
Wheatley, William Coe, The Elms, Trinity-road, Upper Tooting, S.W.
Whitaker, William, 33, East Park-terrace, Southampton.

The paper read was—

RESULTS OF EXPERIMENTS ON MECHANICAL MOTORS FOR TRAMWAYS MADE BY THE JURY ON RAILWAY APPLIANCES AT THE ANTWERP EXHIBITION.

By Captain Douglas Galton, D.C.L., C.B., F.R.S.

An interesting feature of the International Exhibition at Antwerp was the competition which was invited between different forms of mechanical motors on tramways for use in towns, and between different forms of engines for use on light railways in country districts, or as these are termed "Chemins de Fer Vicinaux."

These latter have obtained a considerable development in Belgium, Italy, and other Continental States; and are found to be most valuable as a means of cheapening the cost of transit in thinly peopled districts. But owing to the fact that the Board of Trade regulations in this country have not recognised a different standard of construction for this class of railway from that adopted on main lines, there has been no opportunity for the construction of such lines in England.

There has, however, been a great development of tramway lines in England, which in populous districts supply a want which railways never could fully respond to; and although hitherto mechanical traction has not attained any very considerable extension, it is quite evident that if tramways are to fulfil their object satisfactorily, it must be by means of mechanical traction.

It is also certain that the mechanical motor which shall be found to be most universally adaptable, that is to say, most pliant in accommodating itself to the various lines and to the varying work of the traffic, will be the form of motor which will eventually carry the day.

The competition between different forms of motors at the Antwerp Exhibition, which was carefully superintended, and which was arranged to be carried on for a reasonable time, so as to enable the qualities and defects of the different motors to be ascertained, affords a starting point from which it will be possible to carry on future investigations.

I have, therefore, thought it advantageous to the interests of the community in this country to bring the results arrived at before this Society; and as the "Chemins de Fer Vicinaux," to which one part of the competition was devoted, have no counterpart in this country, it is proposed to limit the present paper to an account of the experiments made on the motors for tramways.

Certain conditions were laid down in the programme published at the opening of the Exhibition, to regulate the competition, in order that the competitors might understand the points which would be taken into account by the judges in awarding the prizes.

The experiments were made upon a line of tramway laid down for the purpose in the City of Antwerp, carried along the boulevards from near the main entrance of the Exhibition to the vicinity of the principal railway station, a distance of 2,292 metres.

The line ended in a triangle of 505 metres, in order that those motors which required to run always in the same direction should be enabled to do so.

Out of the whole length of the line, viz., 2,797 metres, 2,295 metres were in a straight line, 189 metres in curves of $1\frac{3}{4}$ chains radius, and 313 metres in curves of 1 chain radius. There were on the line four passing places, besides a passing place at the terminus; these were joined to the main line by curves of $1\frac{3}{4}$ chains radius.

The line was practically level, the steepest incline being 1 in 1,000; this circumstance is somewhat to be regretted, but the City of Antwerp afforded no convenient locality where a line with steep gradients could have been obtained. The motors were kept in sheds close to the commencement of the line of tramway near the Exhibition, where all necessary cleaning and such minor repairs as were required could take place.

A regular service was established, according to a fixed time-table, to which each motor was required to conform. Each journey was reckoned as starting from the end near the Exhibition, proceeding to the beginning of the triangle, and returning to the starting point. An hour was allowed between the commencement of each journey, fourteen minutes were allowed for a stoppage at the end near the Exhibition, and eighteen minutes at the other end—thus allowing twenty-eight minutes for travelling 2 miles 1,500 yards, or a travelling speed of about 6 miles an hour. The motors were required to work four days out of six, and on one of the four days to draw a supplementary carriage.

An official, assisted by a storekeeper, was appointed to keep a detailed record—

1. Of the work done by each of the motors.
2. Of any delays occurring on the journey, and of the causes of delay.
3. Of the consumption of fuel, both for lighting the fires and for working.
4. Of the consumption of grease.
5. Of the consumption of water.
6. Of all repairs of whatever nature.
7. Of the frequency of cleaning and other necessary operations required for the efficient service of the motor.

The experiments lasted about four months. Five competitors offered themselves, which may be classed as follows:—Three were propelled by the direct action of steam; and two were propelled by stored-up force supplied from fixed engines.

Propelled by the direct action of the steam.

1. The Krauss locomotive engine, separate from the carriage.
2. The Wilkinson locomotive engine (*i.e.*, Black and Hawthorn), also separate from the carriage.
3. The Rowan engine and carriage combined.

Propelled by stored-up force.

4. The Beaumont compressed-air engine.
5. The electric carriage.

It is somewhat to be regretted in the public interest, that other forms of mechanical motors, such as the Mekarski compressed-air engine, or the engine worked with superheated water, or cable tramways, or electrical tramways, were not also presented for competition.

1. The Krauss locomotive is of the general type of a tramway locomotive, but with certain

specialities of construction. It has coupled wheels. The weight is suspended on three points. The water-tanks form part of the framing on each side; a covering conceals all except the dome of the boiler. Above the roof is a surface condenser, consisting of 108 copper tubes placed transversely, each of which has an external diameter of 1·45 inches. The boiler is similar to that of an ordinary locomotive; its axis is 3 feet 10½ inches above the road. The body of the engine is 9 feet 11 inches long, and 7 feet 2½ inches wide. The axles are 4 feet 11 inches from centre to centre. The platform extends along each side of the boiler; the door of the fire-box is in the axis of the road. The engine-driver stands on the right-hand side, in the middle of the motor, where he has command of all the appliances for regulating the movements of the engine as well as of the brake.

The Wilkinson (Black and Hawthorn) engine had a vertical boiler and machinery. The cylinders were on the opposite side of the boiler from the door of the fire-box, and mounted independently; the motion of the piston was communicated by means of a crank shaft and toothed wheels to the driving axle. The wheels were coupled. A regulator, injector, and a hand-brake were placed at each end, so that the engine driver could always stand in the front, whichever was the direction in which the engine moved; and there was a platform of communication between the two ends, carried along one side of the boiler.

The boiler was constructed with "Field" tubes, the horizontal tube plate having a flue in the middle which carried the heated gases into the chimney.

The visible escape of the steam is prevented by superheating. To effect this the steam, as it leaves the cylinder, passes into a cast iron chamber adjacent to the boiler, which is intended to retain the water carried off with the steam. From thence the steam passes into a second chamber, suspended at a small height above the grate in the axis of the boiler and of the flue which conveys the heated gases into the chimney, and thence into a sort of pocket enclosed in the last-mentioned chamber, which is open at the bottom, and the upper part of which terminates in a tube passing into the open air. This method of dissipating the steam avoids the necessity of a condenser; but if it be admitted that the steam in escaping has a minimum temperature of 572° Fahr., it will carry away 12 per cent. more caloric than would have been required to raise it to a pressure of 150 lbs. per square inch.

The steam escaping through the safety valve is passed through the same apparatus.

The toothed wheel on the driving axle is arranged to act upon another toothed wheel on a shaft connected with the regulator, so as to control its speed automatically.

The length of the engine is 10 ft. 10 in., its width 5 ft. 9 in., and the distance from centre to centre of the wheels 5 ft. 2 in.

The Rowan tram-car consists of a body 31 feet long and 7 feet wide, resting on a two-wheeled bogie behind and on a four-wheeled bogie in front, this front bogie being the motor, and the whole has the appearance of a long railway carriage, somewhat in the form of an omnibus with a platform at each end, of which the front platform is occupied by the engine. It requires, therefore, either a turn-table or a triangle at the end of the line, so as to enable it to reverse its direction.

This motor is a steam-engine of light and simple form, supplied with steam from a water tube boiler with very perfect combustion, so that no smoke escapes. The boiler is somewhat on the principle of a Shand and Mason boiler; it is so built that it can easily be opened, and every part of the interior examined and cleaned.

The peculiarity of the Rowan motor is the simplicity of the attachment of the engine to the carriage, and the facility with which it can be detached when required for cleaning or repair, viz., in five or six minutes.

The steam can be got up in the engine with great rapidity if a change of engine is required. When, however, the engine is detached, the carriage loses its support in front, and is therefore not serviceable. When necessary, the combined motor can draw a second ordinary carriage.

The motor by itself occupies a length of 9 ft. 8 in. It has two horizontal cylinders; the four wheels of the bogie are coupled, and between the wheels the sides of the framing are rounded to allow two vertical boilers to stand. These boilers have vertical tubes for the water which are joined together at the top by a horizontal cylinder. Each boiler, with its covering, is 1 ft. 9 in. in diameter. The boilers stand 1 ft. 9 in. apart, thus affording space between them for the motive machinery, including the pump. The crank axle is behind the boilers. The levers, the injector, the access to the fire-box, a pedal for working the engine brake as well as a screw brake for the carriage, are all in front. The brakes act on all six wheels, are worked by the driver, and the whole weight of the engine, car, and passengers being carried on these wheels, the car can be stopped almost instantaneously; and as over two-thirds of the entire weight of the car and passengers rests on the four driving wheels, there is always sufficient adhesion on all reasonable inclines, of and the adhesion is augmented as the number passengers carried increases. Hence this car is adapted for lines with heavy grades.

A small water-tank is attached to the framing; two small boxes for coal or coke, with a cubic capacity of about 3½ feet, are attached to the plate in front of the bogie. The covering of the boilers is in two parts, which are put on from each side horizontally, and screwed together in the centre. The removal of the upper part enables the tubes to be examined and cleaned. The draught is natural; the base of the chimney is 3 ft. 2 in. from the grate; the height of the chimney is 5 ft. 2 in.

The steam from the cylinders passes directly into a condenser placed on the top of the carriage. The condenser is made of corrugated copper sheets millimetre thick. Two sheets, about 15 to 18 inches wide and 15 feet long, are laid together and firmly soldered, forming a chamber. Twenty of these chambers are placed side by side on the top of the carriage, connected with a tube at each end, so as to allow the steam to pass freely through them. The lower corrugations in the several chambers are connected together, and thence a pipe with a syphon to stop the steam is carried to a water-tank under the carriage, which thus receives the condensed water. This arrangement afforded a condensing surface of about 800 square feet. It should be mentioned that with larger engines Mr. Rowan employs as much as 1,600 feet of condensing surface. The nearness of the chambers to each other tends no doubt to diminish the power of condensing the steam, but this is somewhat compensated by the artificial circulation of air produced by the movement of the carriage. But in any case, if there is surplus steam, the pipe from the condenser causes it to pass under the grate, whence it rises superheated and invisible through the fire and up the chimney.

Under the carriage attached to the framing are four reservoirs, holding about three-and-a-half cubic feet of water, of which water space one half acts as a reservoir for cold feed water, and half for the condensed water. A tube from the small reservoir on the engine communicates through valves with the reservoirs of hot and cold water on the carriage.

The consumption of cold water measured during two days was 2·86 lbs. per kilometre; assuming that the boiler evaporated 6·5 lbs. of water per pound of coal, the cold water formed one-fifth of the total feed water required.

The carriage, *i.e.*, the part occupied by passengers, is 21 ft. 3 in. in length. It holds seats for forty-five passengers, besides those who would stand on the gangway and platform. The seats are placed transversely on each side of a central corridor, each seat holding two people. The platform of the carriage is about 2 ft. 6 in. above the rails. Passengers have access to the interior from behind by means of the end platform, and in front near the engine from the two sides. As already mentioned, the hind part of the carriage rests upon two wheels, the front part being, as already mentioned, supported on the engine bogie. To effect this support, the hinder part of the framing of the engine is formed in a half circle, with a broad groove, in which the ends of two springs are arranged to slide. The centres of the springs form the support of the framing of the carriage.

The framing of the engine bogie is attached to the hind bogie truck of the carriage by two diagonal drawbars. The coupling is effected by bolts close to the engine, and the car is drawn entirely by means of the bogie pin of the hind bogie. The trucks are 16·5 ft. apart.

Table I. (p. 161) shows the dimensions of different parts of these three steam motors, as well as their weights.

The Beaumont engine, worked by compressed air, may be generally said to be similar to that described in a paper read before the Society of Arts on the 16th March, 1881, to which, however, some improvements have been since introduced.

The apparatus for compressing the air was placed in the shed. The air was compressed to 63 atmospheres by a pump worked by a steam-engine, and stored in cylindrical reservoirs of wrought iron without rivets. A pipe led the air from the reservoirs to the head of the tramway, where the cylinder placed on the motor for storing the air during the journey could be conveniently charged.

The air was compressed by means of four pumps, placed two and two in a water-box, and worked by the direct action of a compound

TABLE I.

		Krauss.	Wilkinson.	Rowan.
Diameter of cylinder	d	5·5 in.	6·5 in.	5·1 in.
Length of stroke	l	11·8 in.	9 in.	9·8 in.
Diameter of wheels	D	31·5 in.	27·5 in.	29·5 in.
Pressure at which boiler is worked	p	220 lbs.	147 lbs.	191 lbs.
$\frac{p\, d^2\, l}{2 \cdot D}$	E	1,210 lbs.	1,509 lbs.	805 lbs.
Total heating surface	S	105 sq. ft.	105 sq. ft.	64 sq. ft.
Grate surface	G	2·7 sq. ft.	5·4 sq. ft.	3·1 sq. ft.
Surface of condenser	C	274·482 sq. ft.	None	861·120 sq. ft.
Weight in running order (motor only)	P'	15,400 lbs.	15,400 lbs.	9,020 lbs-
Do. do. (total)	P''	..	..	15,400 lbs,
Contents of water tank	..	28·24 cub. ft.	13 cub. ft.	4·2 cub. ft.
Do. coal bunks	..	14·12 cub. ft.	12·5 cub. ft.	3·5 cub. ft.
	$\frac{P'}{E}$	12·7 lbs.	10·2 lbs.	11·2 lbs.
	$\frac{P''}{E}$	..	..	19·125 lbs.
	$\frac{P'}{S}$	146	147	140
	$\frac{P'}{G}$	5,722	2,855	2,889
	$\frac{C}{S}$	2·6	..	13·4
	$\frac{C}{G}$	102	..	275

engine with cylinders placed in juxta-position, of 8 in. and 14 in. diameter respectively, with an equal length of stroke of 13 in.

The air, after being forced through the first pump cylinder, passed successively through the other three, the diameters of which were of proportionately decreasing sizes, viz.:—8·2 in., 5 in., 3·5 in., and 2 in., and the air on leaving each cylinder passed on its way to the next cylinder through a coiled pipe immersed in flowing water to remove the heat generated. This cooling surface amounted to nearly 54 sq. ft.

The cooling of the air was very efficient. In an experiment made on this question, the temperature of the compressor did not vary to the extent of 9° Fahr. in charging the reservoir from 40 to 63 atmospheres, occupying an hour and a half, the consumption of water during the time being about 1,400 gallons.

The fixed reservoirs were of about 240 cubic feet capacity.

The motor formed part of a compound vehicle, which may be said to have consisted of two parts joined together by an articulated corridor, the whole being covered by a roof which was approached from the platform behind by an easy staircase. On this roof were seats for outside passengers.

The front part of the compound vehicle contained the motor, as well as a compartment for six inside passengers, with roof space for twenty passengers, and weighed about 15,400 lbs. when empty; the hind part contained accommodation inside for twelve passengers, and outside for fourteen passengers, and weighed 6,600 lbs.

The combined vehicle was entered from the platform in the rear, which could hold four passengers, and from thence, as already mentioned, the staircase led on to the roof. The total number of passengers this vehicle could accommodate was thus — eighteen inside, thirty-four on the roof, four on the platform, or fifty-six in all.

The total length of the carriage was 29 ft. 7 in., the width 7 ft. The distance between the axes of the bogies was 16 ft. 9 in. The distances apart of the centres of the wheels were, in the case of the hind bogie 3 ft. 9 in., and in the case of the front bogie 4 ft. 4·6 in.

The motor is a compound engine, the diameters of the cylinders being 4·9 inches, and 1·9 inches, with a 12 inch stroke. The diameter of the wheels was 2 ft. 4 in. A small boiler is placed on one side, in front, for creating steam, which passes into a steam-jacket, enclosing the pipe of communication from the reservoir to the cylinders, as well as the cylinders themselves, so that the air was warmed before it escaped. The reservoirs on the motor contained 71 cubic feet.

In an experiment made on charging the reservoir in the motor, the pressure in the fixed reservoirs, at the time of charging the reservoirs on the motor, was 63·8 atmospheres, at a temperature of 68° Fahr. One atmosphere was lost by letting the air into the pipe laid between the shed and the tramway where the motor stood; when the reservoir on the motor was charged, the pressure fell to 42·6 atmospheres in the fixed reservoirs, at a temperature of 55° Fahr.

The pressure in the reservoir on the motor, when ready to start, was 42·6 atmospheres, at a temperature of 84° Fahr. On its return, at the end of forty-six minutes, after a journey as above mentioned of about 3¼ miles including the triangle, the pressure had fallen to 20·9 atmospheres, and the temperature to 71° Fahr. The weight of air used during the journey was thus about 110 lbs., or, say, 34 lbs. per mile. The coal consumed by the stationary engine to compress the air amounted to 39 lbs. per mile, in addition to 3 lbs. of coke per mile for warming the exhaust.

Whilst the motor was performing its journey, the stationary steam-engine was employed in raising the pressure in the fixed cylinders to 63 atmospheres, and worked, on an average, during fifty minutes in each hour; during the rest of the journey it remained idle. It was thus always employed in doing work in excess of the pressure which could be utilised on the car, and the work was, under the circumstances of the case, necessarily intermittent. This was a very unfavourable condition of working.

In the electric tram-car the haulage was effected by means of accumulators. The car was of the ordinary type with two platforms. It was said to have been running as an ordinary tram-car since 1876. It had been altered in 1884 by raising the body about six inches, so as to lift it clear of the wheels, in order to allow the space under the seats to be available for receiving the accumulators, which consisted of Faure batteries of a modified construction. The accumulators employed were of an improved kind, devised by M. Julien, the under manager of the Compagnie l'Electrique, which undertook the work.

The principal modification consists in the substitution, for the lead core of the plates, of one composed of a new unalterable metal. By this change the resistance is considerably diminished, the electromotive forco rises to 2·40 volts, the return is greater, the output more constant, and the weight is considerably reduced. The plates being no longer subject to deformation, have the prospect of lasting indefinitely. The accumulators used were constructed in August, 1884.

The car, as altered, had been running as an electric tram-car on the Brussels tramways since October, 1884, till it was transferred to the experimental tramway at Antwerp. The accumulators had been in use upon the car during the whole of this period, and they were in good order at the end of the experiments, that is to say, when the Exhibition closed at the end of October, 1885.

The accumulator had forty elements, divided into four series, each series communicating by means of wires fixed to the floor of the car, with commutators which connected them with the dynamo used as a motor.

There were two sets of these batteries or accumulators, one of which was being charged in the shed whilst the other was in use. The exchange required ten minutes, including the time for the car to go off the tramway into the shed and return to the tramway. This exchange took place after every seven journeys. Therefore, the two batteries would have sufficed for working the car over a distance of about 42 miles during 16 hours.

It may be observed that the first service in the morning would be performed by means of the accumulators charged during the afternoon and evening of the previous day.

Each element of a battery was composed of 19 plates, of which 9 were positive, 4 millimetres thick, and 10 negative, 3 millimetres thick. Each positive plate weighed 1·44 lbs., of which about 25 per cent. consisted of active material. Each negative plate weighed nearly 1 lb., of which one-third consisted of active matter. The weight of the metallic part of the battery amounted, therefore, to 1,846 lbs.; and the whole battery, including the case and the liquid, amounted to 2,464 lbs., which contained 499 lbs. of active matter, or about 20·25 per cent. The four cases in which the battery was contained were so arranged as to divide the weight equally between the wheels.

Two commutators enclosed in a box were placed on the platforms at the two ends of the carriage, so as to be available for moving in either direction.

The accumulators were divided into four series of ten double elements, which, by means of the commutators, could be united under four combinations, viz:—

1st. 4 series in quantity—1 in tension.
2nd. 2 ,, ,, ,, 2 ,,
3rd. .... 3 ,,
4th. .... 4 ,,

Finally, a fifth movement united the four series in quantity, coupling them on each other, and putting the dynamo out of circuit, thus restoring equilibrium. When in a state of repose the handle was so arranged as to keep this latter switch turned on. The accumulators were arranged for charging in two series united in quantity, each containing twenty double elements. The charge was effected by a Gramme machine, worked by a portable engine. Each of these series received its charge during seven hours for the ordinary service of the car, and during nine hours for the accelerated service.

The accumulators on the car actuated a Siemens dynamo, acting as a motor, such as is used for lighting, having a normal speed of 1,000 revolutions, fixed on the frame of the carriage. The motion was conveyed from the pulley on the dynamo by means of a belt passing round a shaft fixed on moveable bearings to regulate its tension, and thence to the axles by means of a flat chain of phospor bronze. The chain was adopted as the means of moving the axle, on account of its simplicity and facility of repair by unskilled labour.

The speed was fixed at 4 metres per second (which corresponds with a speed of nearly 9 miles per hour), for 1,000 revolutions of the dynamo; and it was regulated by cutting a certain number of the accumulators out of circuit, instead of by the device of inserting resistances which cause a waste of energy. By breaking the circuit entirely the motive power ceased, and the vehicle might either be stopped by the brakes or allowed to run forward by gravity, if the road were sufficiently inclined. The reversal of the motor was effected by means of a lever which reversed the position of the brushes of the dynamo.

The dynamo could be set in motion, and the carriage worked from either end, as desired. The handle to effect this was moveable, and as there was only one handle and this one was in charge of the conductor, he used it at either end as required.

It should be mentioned that the car was lighted at night by two incandescent lamps, which absorbed 1·5 ampères each; and the brakes also were worked by the accumulators.

The weight of the tram-car was 5,654 lbs.; the weight of the accumulators was 2,460 lbs.; the weight of the machinery, including dynamo, 1,232 lbs. The car contained room for fourteen persons inside and twenty outside. Under the conditions of the competition the car was required to draw a second car occasionally.

The jury made special observations upon the work required to move the car between the 20th September and 15th October, 1885. Seals were attached to the accumulators. Moreover, from the 27th of September, after each charge, seals were placed on the belts from the steam-engine to prevent any movement of the Gramme machine, so that there could be no charges put into the accumulators beyond those measured by the jury.

The instruments used for measuring were Ayrton's ampère meter and Deprez's volt meter, which had been tested in the Exhibition by the Commission for Experiments on Electrical Instruments, under the presidency of Professor Rousseau. Besides this Siemens electro dynamometer and Ayrton's voltmeter were used to check the results; but there was no practical difference discovered. During the period of charging the accumulators, the intensity of the current and the electro motive force was measured every quarter of an hour, and thence the energy stored up in the battery was deduced. It may be mentioned that the charge in the accumulators, when the experiments were commenced, was equal in amount to that at their termination.

An experiment was made on 21st October to ascertain, as a practical question, what was the work absorbed by the Gramme machine in charging the accumulators. The work transmitted from the steam-engine was measured every quarter of an hour by a Siemens dynamometer, at the same time the intensity of the electromotive force given out by the machine, as well as the number of the revolutions it was making, was noted. It resulted that for a mean development of 4-mechanical horse power, the dynamometer gave into the accumulators to be stored up 2·28-electrical horse power, or 57 per cent. The intensity varied between 25·03 and 23·51 ampères during the whole time of charging. Of this amount stored up in the accumulators a further loss took place in working the motor; so that from 30 to 40 per cent. of the work originally given out by the steam-engine must be taken as the utmost useful effect on the rail.

It was estimated that to draw the carriage on the level .714-horse power was required, or if a second carriage was attached, ·848-horse power would draw the two together. This would mean that, say, 2-horse power on the fixed engine would be employed to create the electricity, for producing the energy required to draw the carriage on the level.

The electric tram-car was quite equal in speed to those driven by steam or compressed air, and was characterised by its noiselessness and by the care with which it was manipulated.

Assuming the car, by itself, cost the same as an ordinary tram-car, the extra cost relatively to other systems was stated as being, according to the following figures, viz.;—The Gramme machine cost £48, the motor £208, and the accumulators 2·25 francs per kilogramme (10d. per pound). To these must be added the cost of erection, and of switches for manipulating the current; as well as the proportion of the cost of a fixed engine to create the electricity.

Having thus given a general description of the various motors which were presented for competition, I will now give a brief summary of some of the principal particulars obtained during the competition. In the first place, it may be mentioned that the Jury consisted of the following:—

President.—M. Hubert, Ingénieur en Chef, Inspecteur de Direction à l'administration des chemins de fer de l'Etat Belge.

Vice-President.—M. Beliard, Ingénieur des Arts et Manufactures, délégué par le Gouvernement Français.

Members.—M. M. Douglas Galton, Capitaine du Génie, délégué par le Gouvernement Anglais; Gunther, Ingénienr, Commissaire Général de la Section allemande à l' Exposition d'Anvers; Huberti, Ingénieur à l'administration des chemins de fer de l'Etat Belge, Professeur à l' Université de Bruxelles; Dery, Ingénieur Chef de service à l'administration des chemins de fer de l'Etat Belge.

Secretary.—M. Dupuich, Ingénieur Chef du service du matérial et de la traction à la Société Générale des chemins de fer économiques.

Reporter.—M. Belleroche, Ingénieur en Chef, à la traction et au matérial des chemins de fer du Grand Central.

Members added by the Jury. — MM. Vinçotte, Ingénieur, Directeur de l' Association pour la surveillance des machines à vapeur; Laurent, Ingénieur des mines et de l'Institut électro-technique de l'Universite de Liége.

The original programme of the conditions which were laid down in the invitation to competitors, as those upon which the adjudication of merit would be awarded, contained twenty heads, to each of which a certain value was to be attached; and, in addition to these special heads, there were also to be weighed the following general considerations, viz.:—

a. The defects or inconveniences established in the course of the trials.

b. The necessity or otherwise of turning the motor, or the carriage with motor, at the termini.

c. Whether one or two men would be required for the management of the engine.

As regards these preliminary special points, the compressed air motor, as well as the Rowan engine, required to be turned for the return journey, whereas the other motors could run in either direction.

In regard to this, the electric car was peculiarly manageable, as it moved in either direction, and the handle by which it was managed was always in front, close to the brake. This carriage was the only one which was entirely free from the necessity of attending to the fire during the progress of the journey, for even the compressed air engine had its small furnace and boiler for heating the air.

Each of the motors under trial was managed by one man.

The several conditions of the programme may be conveniently classified in three groups, under the letters A, B, C. Under the letter A have been classed accessory considerations, such as those of safety and of police. These are of special importance in towns. But their relative importance varies somewhat with the habits of the people as well as with the requirements of the authorities; for instance, in one locality or country conditions are not objected to, which in another locality are considered entirely prohibitory.

The conditions under this head are:—

1. Absence of steam.
2. Absence of smoke and cinders.
3. Absence, more or less complete, of noise.
4. Elegance of aspect.
5. The facility with which the motor can be separated from the carriage itself.
6. Capacity of the brake for acting upon the greatest possible number of wheels of the vehicle or vehicles.
7. The degree to which the outside covering of the motor conceals the machinery from the public, whilst allowing it to be visible and accessible in all parts to the engineer.
8. Facility of communication between the engineer and the conductor of the train.

In deciding upon the relative merits of the several motors, so far as the eight points included under this heading are concerned, it is clear that, except possibly as regards absence of noise, the electrical car surpassed all the others.

The compressed air car followed, in its superiority in respect of the first three points, viz., absence of steam, absence of smoke, and absence of noise; but the Rowan was considered superior in respect of the other points included in this class.

Under the letter B have been classed considerations of maintenance and construction.

9. Protection, more or less complete, of the machinery against the action of dust and mud.
10. Regularity and smoothness of motion.
11. Capacity for passing over curves of small radius.
12. The simplest and most rational construction.
13. Facility for inspecting and cleaning the interior of the boilers.
14. Dead weight of the train compared with the number of places.
15. Effective power of traction when the carriages are completely full.
16. Rapidity with which the motor can be taken out of the shed and made ready for running.
17. The longest daily service without stops other than those compatible with the requirements of the service.
18. Cost of maintenance per kilometre. (It was assumed, for the purposes of this subheading, that the motor or carriage which gave the best results under the conditions relating to paragraphs 9, 10, 12, and 13, would be least costly for repairs.)

As regards the first of these, viz., protection of the machinery against dirt, the machinery of the electrical car had no protection. It was not found in the experiments at Antwerp that inconvenience resulted from this; but it is a question whether in very dusty localities, and especially in a locality where there is metallic dust, the absence of protection might not entail serious difficulties, and even cause the destruction of parts of the machinery.

In respect of the smoothness of motion and facility of passing curves, the cars did not present very material differences, except that the cars in which the motor formed part of the car had the preference.

In the case of simplicity of construction, it is evident that the simplest and most rational construction is that of a car which depends on itself for its movement, which can move in either direction with equal facility, which can be applied to any existing tramway without expense for altering the road, and the use of which will not throw out of employment vehicles already used on the lines; the electric car fulfilled this condition best, as also the condition numbered 13, as it possessed no boiler.

In respect to No. 14, viz., the ratio of the dead-weight of the train to passengers, if we assume 154 lbs. as the average weight per passenger, the following is the result in respect of the three cars in which the power formed part of the car:—

$$\text{Electric car} \ldots\ldots \frac{9{,}350 \text{ lbs.}}{154 \times 34} = 1{\cdot}78.$$

$$\text{Rowan} \ldots\ldots\ldots \frac{15{,}950 \text{ lbs.}}{154 \times 45} = 2{\cdot}30.$$

$$\text{Compressed air} \ldots \frac{22{,}000 \text{ lbs.}}{154 \times 56} = 2{\cdot}55$$

The detached engines gave, of course, less favourable results under this head.

Under head No. 15 the tractive power of all the motors was sufficient during the trials, but the line was practically level, therefore this question could only be resolved theoretically, so far as these trials were concerned, and the Table before given affords all the necessary data for the theoretical calculation.

As regards the rapidity with which the motors could be brought into use from standing empty in the shed, the electric car could receive its accumulators more rapidly than could the boiler for heating the exhaust of the compressed-air car be brought into use.

As regards the steam motors, the following were the results from the time of lighting the fires:—

The Rowan—

In 34 minutes .... 3 atmospheres.
36 ,, ... 4 ,,
(At this pressure the vehicle could move.)
40 ,, ... 8 ,,

The Wilkinson—

In 35 minutes .... 2 atmospheres.
40 ,, ... 4 ,,
44 ,, ... 6 ,,
47 ,, ... 8 ,,

The Krauss machine required two hours to give 6 atmospheres, which was the lowest pressure at which it could be worked.

The results under No. 17, viz., the fewest interruptions to the daily service, class the motors in the following order—Krauss, electric, Rowan, Wilkinson, compressed air. The chief cause of injury to the compressed air motor arose from the carelessness of the drivers, who allowed the steam boiler to be burnt out. Unfortunately, these drivers were new to the work.

Under the letter C are classed considerations of economy in the consumption of materials used for generating the power necessary for working.

19. Minimum consumption of fuel (either coke or coal), in proportion to the number of kilometres run, and to the number of places, assuming for the seats a width of at least sixteen inches for each person seated.

It must be borne in mind that the conditions of the competition required that a second car should be periodically drawn by the motor, and that the calculations which follow include the total number of miles run, the total amount of fuel, &c., consumed; and the total number of passengers which could be conveyed by each motor, during the total time that the experiments were being carried on.

TABLE II.

Description of motor.	Total number of train miles run.	Total consumption of fuel.	No. of lbs. per train mile.
Electric......	2,358·9	lbs. 14,786·	6·16
Rowan	2,616·9	14,498·	5·42
Wilkinson ..	2,473·3	22,000·	8·82
Krauss	2,457·8	22,726·	9·10
Compressed air	2,259·1	90,420·	39·48

TABLE III.

Description of motor.	No. of places indicated on the cars, per mile run.	Consumption of fuel.	No. of lbs. of fuel consumed per places indicated per mile run.
Electric......	80,203·5	lbs. 14,786·	·18
Rowan	148,399·6	14,498·	·09
Wilkinson ..	119,085·1	22,000·	·18
Krauss	108,983·9	22,726·	·20
Compressed air	128,189·3	90,420·	·69

TABLE IV.

Description of motor.	No. of seats per mile run.	Consumption of fuel.	No. of lbs. of fuel consumed per seat per mile run.
Electric......	61,591·2	lbs. 14,786·	·23
Rowan	135,928·8	14,498·	·10
Wilkinson ..	93,965·6	22,000·	·23
Krauss	86,039·9	22,726·	·25
Compressed air	132,732·7	90,420·	·66

As regards the figures in these Tables, it is to be observed that the consumption of fuel for the electric car is, to a certain extent, an estimate; because the engine which furnished the electricity to the motor also supplied electricity for electric lights, as well as for an experimental electric motor which was running on the lines of tramway, but was not brought into competition.

20. Minimum consumption of oil, of grease, tallow, &c. (the same conditions as in No. 19).

TABLE V.

Description of motor.	Total number of miles run.	Total consumption of oil, tallow, &c.	Consumption of oil, tallow, &c., per train mile run.
		lbs.	
Electric......	2,358·9	99·0	·038
Rowan	2,616·9	106·7	·038
Krauss	2,457·8	188·5	·073
Wilkinson ..	2,473·3	255·4	·101
Compressed air	2,259·1	585·2	·255

In addition to these considerations, it was thought useful to investigate the quantity of water consumed in the case of these engines which used steam. The experiments made on this point showed as the consumption of water

	Gallons per mile.
Rowan	·75
Compressed air..............	1·06
Wilkinson	5·89
Krauss	6·52

Thus, owing to the large proportion of water returned from the condenser to the tanks, the Rowan actually used less water than the compressed-air engine.

CONCLUSION.

The general conclusion to which these experiments bring us is that, undoubtedly, if it could certainly be relied upon, the electric car would be the preferable form of tramway motor in towns, because it is simply a self-contained ordinary tram-car, and in a town the service requires a number of separate cars, occupying as small a space each as is compatible with accommodating the passengers, and which follow each other at rapid intervals.

But the practicability and the economy of a system of electric tram-cars has yet to be proved; for the experiments at Antwerp, whilst they show the perfection of the electric car as a means of conveyance, have not yet finally determined all the questions which arise in the consideration of the subject. For instance, with regard to economy, the engine employed to generate the electricity was not in thoroughly good order, and from its being used to do other work than charging the accumulators of the tram-car, the consumption of fuel had to be to some extent estimated. In the next place, the durability of the accumulators is still to be ascertained; upon this much of the economy would depend. And in addition to this question, there is also that of the durability of parts of the machinery if exposed to dust and mud.

After the electric car, there is no question but that, at the Antwerp Exhibition, the most taking of the tramway motors was the Rowan, which was very economical in fuel, quite free from the appearance of steam, and very convenient and manageable.

The economy of the Rowan motor arises in a large degree from the extent of its condensing power, by means of which a considerable supply of warm water is constantly supplied for use in the boiler, and, consequently, the quantity of water which has to be carried is lessened, and the fuel is economised.

Independently, however, of its convenience as a motor for tramways in towns, the Rowan machine has been adapted on the Continent to the conveyance of goods as well as passenger traffic on light branch railways, and fitted to pass over curves of 50 feet radius, and up gradients of 1 : 10.

In England, with our depressed trade and agriculture, there is a great want in many parts of the country of a cheap means of conveyance from the railway stations into the surrounding districts; such a means of conveyance might be afforded by light railways along or near the road-side, the cost of which would be comparatively small, provided that the expensive methods of construction, of signalling, and of working, which have been required for main lines, and which are perfectly unnecessary for such light railways, were dispensed with.

It is certain that this question will acquire prominence as soon as a system of local goverment has been adopted, in which the wants of the several communities have full opportunity of asserting themselves, and in which each local authority shall have power to decide on those measures which are essential to the development of the resources of its own district, without interference from a centralised bureaucracy.

DISCUSSION.

Mr. PREECE, F.R.S., said he was a juryman at the Antwerp Exhibition, and though his official duties did not require him to inspect and report upon these tram-cars, he took every possible opportunity of examining them, and being an electrician, of travelling backwards and forwards on the electric car. He was delighted to find that the anticipations he formed, at an early period of the Exhibition, had been fully borne out by what Captain Galton had said. At the same time it was rather difficult to discover in what respect this particular car differed from others of a similar kind which had been experimented on in England. The chief advantage it had, seemed to him to be that it had been examined and reported on by Captain Douglas Galton. One very similar ran backwards and forwards for some time in the works of the Electric Power Storage Company at Millwall, and one designed by Mr. Reckenzaun had been running some time in Berlin. He tried to find out the special features of the accumulator used by M. Julien, but failed to do so. It was said to be formed on a framework of some nnalterable metal, but he did not discover what it was; he heard by a side-wind that it was nickel, but at any rate, as far as the performance and appearance went, he could see no difference between it and those used in England. At different times, he had inspected and ridden on various electric tram-cars, some driven direct by the current, like that at Portrush, or the one at Cleveland, United States, the only difference in these two being that the current in Ireland was of low tension, and that in the United States was of high tension. There was also one which he had not seen at Blackpool. As an electrician, he had seen very great difficulties in carrying out a system of tramways worked by electricity, but, like all other difficulties, experience and study succeeded in removing them, and he had the greatest confidence in the future use of electricity for this purpose, whether applied directly or by the aid of accumulators. There was a great want of confidence in this latter system, the reason for which was not hard to discover, because they were thrust on the world long before either it was ready to receive them or they were properly developed. One of the first places in which the tide began to turn was in the Society of Arts. Some time back they had succeeded in lighting the hall by means of accumulators, and all present could see with what absolute steadiness the light was maintained. Captain Galton, at the end of the paper, said that undoubtedly if it could be relied on electricity would be the best motor for tramways; and that was the way in which everyone spoke of it. But there was no power on earth used for the service of man which could be so certainly relied on as electricity. These doubts were due to the fact that the early applications of electricity were so striking in their character, such for instance as reproducing speech by the telephone, that they at once caught the attention of the public, who at once believed the thing was perfection before it had really reached the practical stage. So it was with the accumulator; the idea of storing up a horse-power in a deal box appealed to the public imagination, and when the fact was first published in the *Times*, that a certain gentleman brought such a box from Paris to Sir William Thomson, in Edinburgh, inordinate expectations were raised; then when it was not found at first a practical instrument, they began to use such expressions as he had referred to, and thought it could not be relied on. He had no doubt, however, we should yet live to see in London and the suburbs, the Antwerp experiments repeated on a much larger scale.

Mr. A. RECKENZAUN said thiswas one of the most interesting and practical papers ever read on the subject of the mechanical propulsion of tram-cars, but it would have been still more useful had the experiments been carried out on a line presenting more difficulties. It was very easy to travel on a level line, but very difficult to travel on an incline. For instance, if it required 2 horse-power on the level, it would take 4 horse-power to go at the same speed up a gradient of 1 in 75, 6 horse-power for a gradient of 1 in 37, and 8 horse-power for 1 in 25, which was not very serious after all. Again, the sharpest curve on the line at Antwerp was only of a radius of one chain, and he was rather surprised it was not made sharper. He had recently been running a car in Berlin, where he had received much more encouragement than in London, and he believed a fair amount of business would be done there before any start was made in England at all. There, one curve was 11 metres radius, and there were several of 15 metres. In the Antwerp tram it appeared there was a certain amount of noise caused by the chain gear, and this kind of gearing was not very practical in the case of a tramway where there was a deal of dirt to guard against. He had adopted a worm wheel, such as was shown on a large drawing of his tram-car on the wall. Many experienced engineers advised him not to use this gearing, but having arranged it so that the wheel dipped into an oil bath, and the whole boxed in, so that little or no dirt could find access, he found that there was not nearly so much loss by friction as had been stated, previous experiments having all been made apparently at low speeds, and showing an efficiency varying between 30 and 50 per cent. He found, however, that he got as much as 80 to 85 per cent., which was as much as could be got with a chain. He had two motors, so that the speed or power could be varied at will. One motor would propel the car along a level road, and it would run down an incline of 1 in 70 by its own momentum, which showed how little friction there was. The two motors in parallel arc would drive it up an incline of 1 in 18, and the two were used in series at starting, when the electric resistance was greatest, so that the current flowing then should be the smallest possible. With regard to the wonderfully lasting accumulators which it was said Mr. Julien had discovered, he would only say that if the plates lasted only six or eight months electrical cars would still be more economical than horses. Although the efficiency of the whole apparatus between the steam-engine and the car wheels could not be taken at more than 30 to 40 per cent. (he reckoned it at 33), still it was economical to use electricity, because the accumulators only weighed 1¼ ton, and the whole of the rest of the machinery weighed half a ton, making 1¾ ton altogether, which compared very favourable to a locomotive weighing eight to ten tons. You could, therefore, afford to lose 60 to 70 per cent. of your motive power. He ought to say that he was much indebted to the Electric Power Storage Company, who had assisted him very materially in bringing this car to perfection. He had been working at it for four years, but it was only within the last twelve months he had arrived at a practical result. The first question was, to produce an accumulator which was light, and at the same time durable and efficient. The main advantages of this system were, first, economy, and second, the electric car had the same appearance as those in general use, which could be easily converted, and at small cost. The wearing parts of the mechanism were very few, and could be easily replaced. The weight of motive power was less than two tons, distributed over two small bogies of four wheels each, so that the actual weight on a given section of the rail was less than that of an ordinary car resting on four wheels only. The propelling apparatus was invisible to the passengers; the motor was boxed in completely; it was practically noiseless, and free from danger. One man not necessarily skilled, could drive the car, which could also be illuminated at night by the electric current. Of course, the maintenance of the permanent way would cost less than where horses were used, and the charging stations would occupy less space than the stables.

Mr. W. R. Rowan could not agree with the two previous speakers. As far as he could gather, the contest at Antwerp was really between two combined cars, the electric car, and the steam-car which he had designed. Having been there some eight or ten weeks, he could bear testimony to the great care and trouble taken by the jury over this question. There was no doubt that the most taking car was the electric motor, but the whole question from the first hinged on one word—economy, and the question would turn out to be, which was most economical, steam used directly in driving the car, or to produce electricity or compress air, which should then drive it. The electric car had all the advantages on its side as regarded appearance and other qualities which might be desired in a motor for towns, but he thought it would be difficult for the jury to decide on the question of economy. There were four main difficulties which he thought it would take electricians some time to get over. The first was the transmission of the power. The use of a belt or chain was not generally supposed to be satisfactory, and he had his doubts about the worm wheel. If electricians could discover a gearing which would enable them to work from a shaft running at 1,000, or even 500, revolutions a minute, those who employed steam would be very glad, because they could use it with small engines running rapidly. Such a style of engine was what naturally suggested itself for this purpose, but hitherto it could not be used on account of the difficulty in transmitting the power. The second difficulty was that of the accumulators; would they really last if knocked about daily in a tramcar. The trial at Antwerp gave very little information on that point, being short, straight, and level, so that they only had to be charged once a day. Had it been a line such as Mr. Reckenzaun mentioned, they would require charging four or five times a day. There was as yet no proof that the accumulators would stand, and if they had to be renewed even every year, the cost would be greater than that of maintaining a properly constructed steam-engine. On a recent visit to Brussels, he learned that the Company had voted 25,000 francs towards the establishment of a regular electric service on one of the lines there, in order to test this question; but he felt pretty confident that one or two years' trial would not lead to horses being superseded by electricity. The third difficulty was the charging of the accumulators. In running up steep grades, and with grooved rails, which added greatly to the friction, he believed the accumulators would have to be charged five times a day, which would be a practical difficulty. Lastly, if all these difficulties could be overcome, he doubted if they could work as cheaply as with steam direct, seeing that only 25 to 40 per cent. of the power would be utilised. The question of the power utilised, however, did not play an important part in tramway maintenance, the whole secret of mechanical tramway work would lie in having a motor powerful enough under certain circumstances; which would run very cheaply when it had little work to do, but which would work expansively, so that you could put on a second car and carry a large number of passengers when required; and up to the present he ventured to say there was nothing to compete with a simple form of steam-engine, where you had only to put a little more coal on the fire to obtain the necessary power.

Mr. Scott Russell though it a pity Captain Galton had not given some information about the "Chemins de Fer Vicinaux," because in Ireland that sort of railways was being begun. The other day he went over one of these lines, running partly on rails and partly along the road. On the road the locomotives were made to condense their steam; on the railway they worked in the ordinary way. The paper really had not much bearing on tramways in this country, because the conditions were so very different. The rail at Antwerp was an edged rail, in England they were grooved, which gave treble the resistance; and here we had heavy inclines, and in nearly every case the engine or horses had to be detached and turned round. Abroad, steam-engines puffed through the stations without any attempt at condensation; but here the local authorities were so strict that if there were any chance of arriving at perfect condensation, they would certainly insist upon it. He agreed with a great deal of what Mr. Rowan had said with regard to using steam direct; it must be a question of economy, and however much the public liked it, you would never find a tramway company adopting electricity or compressed air unless it paid them. From published results it appeared that the cost of working with a detached steam-engine had been brought down to 3s. 3d. a mile, and no doubt with a combined car it would be still less, as there would be less dead weight; with horses it was 4s. 8d.; and compressed air, taking the results at Nantes, was 5d. a mile. He was rather a believer in compressed air, but did not think either the Mekarski or Beaumont system was likely to be successful, the dead weight being too great. The loss in the compression of air was so enormous, that unless the weight were reduced to a minimum, it could not be worked economically. A much more practical plan had been proposed in America, making a very light car with a low pressure of the air, and tubes carried along the centre of the track, so that the car might be charged when it stopped, by means of a coupling similar to that of the air brake. With regard to electricity, he understood from practical electricians that the theoretical loss from the engines to the accumulators, from them to the dynamo, and from that to the rail, was something like 75 per cent. as a minimum, and he was afraid unless accumulators were made much lighter, they would be found too heavy.

Mr. SCOTT MONCRIEFF said Captain Galton had pointed out what would be admitted more and more as time went on, that certain points, such as simplicity of construction, power of moving in either direction, applicability to existing lines, &c., were of vital importance, and especially that the motor should be self-contained for the purpose of locomotion in crowded thoroughfares. This was the first paper of importance on tramway traction independent of particular interests, and embracing the subject as a whole, and it was very satisfactory that it should be based on a series of practical trials such as those made at Antwerp. At the same time, he agreed that the trials were very unsatisfactory, for the reasons which had been pointed out. The absence of inclines and curves was a fatal objection, because the best motor at Antwerp might get a prize, on the strength of which it might be introduced in a place where it would prove a complete failure. He hoped that public attention being drawn to the matter would lead to similar trials being made in this country before long. Time did not allow of his referring at length to his own work in this direction, but he might say that his first series of experiments with compressed air was the means of inducing the Legislature to permit the use of mechanical traction on urban or suburban tram lines. In 1877, power was given, subject to the approval of the Board of Trade, for mechanical power upon a practically country line at Wantage, and also an urban line in the Vale of Clyde, and his evidence with regard to the success of compressed air led the Parliamentary Committee to recommend the passing of a Bill sanctioning the use of mechanical power. In common with many others, he had been waiting for the ripening of public opinion with regard to the use of mechanical power other than steam. The pressure brought by the Board of Trade on inventors to produce something which would comply with their rules had been more or less relaxed, because no steam-engine had hitherto complied with those requirements all day long. During a certain period, or under certain conditions, the smoke and steam might be successfully suppressed, but after a certain amount of wear and tear it had been absolutely necessary for the Board of Trade requirements to be relaxed, if steam was to be applied to tramways at all. He could not speak as an expert in the matter of electricity, but its advantages, as regarded a self-contained vehicle of good appearance, were evident. Nothing surprised him more in Table No. II. than the extraordinary amount of fuel used by the compressed air engine. It certainly bore no relation at all to the theoretical laws which bore on the conversion of energy from the boiler to the reservoir, and showed some egregious failure in the system. His own experience, as given in evidence in 1877, more nearly approached the Rowan engine, which stood at the head of the list for economy; but, as had been very properly said, if the proper motor were obtained, neither the public nor the companies would cut the matter so fine as to reject it on account of one or two lbs. of coal per train mile. He had urged before the Institute of Mechanical Engineers reasons for believing that in this particular case compressed air would be quite as economical as steam, the most obvious of these reasons being that a very large and powerful engine, embracing all modern improvements, and using a very small quantity of coal per indicated horse-power, might be employed. If such an engine only consumed 3 lbs. of coal, and there were a loss of 50 per cent. on the use of compressed air—which there ought not to be—you would get to practically the same economy as in the Rowan engine, at Antwerp, 5·42 lbs. Then the car itself, although somewhat heavier than an electric car, had still all the good qualities of a self-contained vehicle, capable of surmounting considerable inclines and going round sharp curves. He could not sit down without saying a word on the electric car described by Mr. Reckenzaun. He had long thought that the worm wheel had been a too much abused mechanical appliance, and was not astonished to hear that the loss from friction at high velocities was much less than had been generally supposed. He should be interested to know how this worked in actual practice, but thought from the appearance of the drawing, that it was too slight for the work it had to do.

Mr. B. **Drake** said there were one or two points in connection with the Electric Power Storage Company, which he represented, which he should like to mention. They not only used accumulators at their own works, but had supplied them for trials elsewhere, and in practical working it was found that giving them the full charge, the efficiency in ampères was 75 per cent., and beyond that the loss in energy, expressed in watts, depended on the time at disposal to discharge them. When Mr. Reckenzaun tested them at the works, the power going into the accumulators necessary for each car was reduced to a minimum, and in those trials they were charged up rather quicker than they would be for lighting purposes, and there the efficiency was about 70 per cent. in watts. That experiment had been very carefully conducted, and might be depended upon. With regard to the duration, the same as had been in use for two years were now to be seen at the works; there was very little destruction of the plates, and what there was, was from mere mechanical shaking about. They were all perfectly ready, and if they were wanted to-morrow for an electric car could be put into regular work. M. Julien claimed a good deal in the way of production of local action by his special arrangement, but if one went into the causes of local action it would be seen that, if pure peroxide and pure lead were used, there was no necessity to have any local action at all. They had left batteries standing for six weeks fully charged, and at the end of the time the power was practically equal to what was put in. Whether they were discharged in one week or six weeks, the loss was hardly appreciable. The car at the works, from one cause or another, had not been used for some months, but still they were able to show it that day running without having been been charged or touched for months. It had been stated on behalf of the compressed air car, that stationary engines more economical than any which could be used on a car were applicable; this would also hold good in accumulators with this additional advantage, that in the case of compressed air, assuming that from the moment you started you had by some mechanical arrangement to get over the gradual decrease of power from the air chambers, whereas with accumulators there was practically no loss of locomotor force, from the time of starting until the time when they had gone so low that for the sake of sparing the plates you should not discharge them any further.

Mr. M. **Holroyd Smith** said a good deal had already been said which it was unnecessary for him to repeat, and he only needed to clinch the argument. Mr. Rowan and Mr. Reckenzaun had made comparisons between accumulators and steam traction, the former pointing out that the difficulty with accumulators was that you had to take the power and convert it into electric energy, and then re-convert it into mechanical energy, and that there must be a loss in the transmission. With that he perfectly agreed; on the other hand, Mr. Rowan showed that the tests at Antwerp were unfair on account of the car running on a level without curves, and that where 2 horse-power would be sufficient on a level it would have to be raised to 8 on a gradient of one in 25. Now, he wished to prove that, especially in the case of accumulators, that meant an excessive demand on the stored energy contained in them, and he would venture to prophesy that Mr. Reckenzaun would find that by the manner in which he was now working the accumulators they would very soon be worn out, and he did not see how a tram line could be worked economically if the motive battery in the car lasted only six months. However, he believed he had absolutely solved the question which Captain Douglas Galton had put before them, viz., that, whether electricity could be applied with certainty to the propulsion of cars. He was now doing that, day in day out, from morning to night, at Blackpool. He used electricity direct, and, therefore, there was no loss through the accumulators. The great question with regard to using electricity direct for street purposes was how to do it with safety to the public, and until he laid down this line it had not been done, because one rail had been used for the positive, and the other for the negative current, or some side rail, which would be very dangerous to the traffic, had been applied. By conveying the electricity underground, and having a means of communicating with it in the car, it was possible to utilise it without any danger either to the public or the traffic. That point had been most carefully tested by Major Armstrong. The Major felt a little trepidation at first, and it was not until holding his hand he touched the surface of the centre channel and the surface of the rails at the same time, and could feel no possible shock, that he was satisfied of the fact. The cars were running every day except Sundays; the present being the off-season, there are only three, whereas during the season there would be ten, and of course the same plant had to be put down, and the same electrician, and standing wages had to be paid as if the whole ten were running. It was, therefore, very unfair to take the present experience as a test of what could be done, because when the whole of the cars were running it only meant a little more coal in the engine; but even now the cost was only half that of horsing. On the same line, before the electric plant was completed, horses were employed, and being just at the close of the season they were obtained from omnibus proprietors at a very low price, but still it was double the cost of electricity.

Mr. **Scott Moncrieff** asked what was the actual sum paid.

Mr. M. **Holroyd Smith** said it was rather less than 6d. per mile for the horses, but they were now doing it at half that price; when the whole ten cars were running, it would cost about 2½d. per mile, including depreciation and interest on outlay. The length of the line was over two miles, the steepest gradient 1 in 40, and the sharpest curve one of 48 feet radius, curve and gradient at the same place. The The point he wished to insist upon was the advantage of driving tram-cars direct instead of using accumulators. He did not wish to argue against secondary batteries for tram-car work, for he thought they would serve a very useful and important purpose, by increasing the public confidence in electricity, and then they would be prepared to go the whole length, and use the direct current. At the same time, if you had to go up a gradient of 1 in 20 for a mile and a half, and another of 1 in 30 for two miles, as was the ease in some places in Yorkshire, it required some pulling up, and unless the amount of accumulators in the car were doubled, they would very soon be spent. Electricians knew that it was a very risky thing to quickly exhaust a secondary battery; you might charge them quickly if you liked, but it was a very awkward business to discharge them rapidly. The weight, therefore, would have to be increased, or their life would be shortened. Now, by his system, if the tram-car came to a hill, the man in charge only had to put on a little more resistance, and if necessary the whole power generated at the station might be taken to send the car up the gradient. He could not only take the car, but could draw another behind it loaded with passengers up the steepest incline. Although they had been working through wet, wind, and snow, and the whole line had been deluged with sea water, they had been able to work with a loss from leakage of not more than the ampère of current.

Capt. DOUGLAS GALTON, in reply, said he agreed with the comments which had been made on the line at Antwerp, which certainly did not represent those found in this country, but those who knew Antwerp would be aware that it was impossible to lay down a line there with steep gradients, and even sharp curves could not be made conveniently, having regard to other traffic on the boulevards. The full report of the jury would soon be published in a very complete form, and he hoped all persons would reserve their final opinion until then.

The CHAIRMAN then proposed a cordial vote of thanks to Captain Douglas Galton for his valuable paper, which was carried unanimously.

Mr. C. J. W. JAKEMAN writes:—I have heard Captain Douglas Galton with considerable pleasure, as his paper differs from many on this subject, in that it contains reliable figures and data, gathered from specially conducted public trials. I may say that my firm (Merryweather & Sons) was invited to take part in the trials, but after examining the road, decided that it would be no fair test of the practical working of the engines on ordinary town tramways, with grooved rails, and consequently did not enter the contest. From the figures given in the paper, it appears that Rowan's combined car was most economical in working, and that very little water (three quarters of a gallon per mile only) was required to make up loss; this was probably due to the fact that on a combined car, considerable roof-space is available for the condenser, and not to its construction; as in our experiments with plate condensers we have always found them inferior to tubulous ones, which we have finally adopted. With reference to this point, I may say that with our detached engines working on the North London tramways, with inclines of 1 to 20, only from 10 to 20 gallons of fresh water are required after a run of 11 miles.

The figures relating to the compressed air car are really astonishing, and, unless the principle of workng air at high pressure is altogether wrong, as it possibly is, there must have been some very bad management in the working. The coke alone (3 lbs. per mile), used to warm the air, would have been more than half the quantity of fuel required to drive by steam direct.

Miscellaneous.

FRENCH VINTAGE OF 1885.

In the *Bulletin de Statistique et de Législation Comparée* for the month of December last an article appeared on the French vintage of 1885. It is there stated that the wine crop amounted to 28,536,151 hectolitres, the hectolitres being equivalent to 22 imperial gallons, or a diminution of 6,244,575 hectolitres compared with the previous year, and of 13,672,903 hectolitres taking the average of the last ten years. A falling off in the yield is observable in forty-two departments, and it is particularly marked in Ariège, Aude Charente, Charente-Inferieure, Dordogne, Gard, Haute-Garonne, Gers, Gironde, Hérault, Landes, Marne, Haute Marne, Basses-Pyrénées, Hautes-Pyrénées, Pyrénées-Orientales, Tarn, La Vendée, and Vienne. On the other hand, there was a considerable increase in the wine production in Ain, Allier, Côte-d'Or, Doubs, Isère, Jura, Haute-Loire, Loiret, Nièvre, Puy-de-Dôme, Haute-Saône, Saône-et-Loire, and Yonne. So, therefore, it is in the departments of the Midi that the diminution in the crop is more particularly noticeable, while in the east the result of the harvest has been satisfactory, and in the centre the wine production has remained stationary. One of the principal causes that have contributed to affect the yield were the atmospheric disturbances which occurred during the spring and the greater part of the summer, generally throughout the whole of France. The vines which in April suffered from severe frosts, experienced in July and August long-continued periods of drought, and in some instances suffered from hailstorms. Then the autumn rains which in the Midi exercised a favourable influence on the development of the grape, had the contrary effect in the centre and mountain districts. To these general causes must be added, as regards the Midi, the west, and the district of Charente, the ravages of the phylloxera and the mildew. At the present time there are no less than fifty-four departments in France that have suffered more or less severely from the attacks of phylloxera. The area of the vineyards affected has been estimated to exceed 430,000 hectares, the hectare being equivalent to 2·47 acres, but notwithstanding this fact, the total area under vine cultivation has only decreased to the extent of 50,173 hectares. Active steps have been and continue to be taken, to reconstitute the French vineyards with American vines, and this plan, which has been adopted in thirty-three departments, appears to have been particularly successful last year in the Ardèche and the Lozère. The mildew which was confined to the department of the Ain, Gard, Basses-Pyrénées, and Vaucluse, and certain districts of the Bouches du Rhône and the Landes, has now made its appearance in the Aude, Dordogne, Haute Garonne, Gironde, Isère, Lot-et-Garonne, Hautes-Pyrénées, Pyrénées-Orientales, Deux-Sevres, and Tarn-et-Garonne. To resist the attacks of the phylloxera many remedies have been applied with varying results, and the latest one which appears hitherto to have been particularly successful consists in syringing the vines with a solution of whitewash and sulphate of copper. The adoption of this plan was advocated by one of the staff of the Ministry of Agriculture, who was lately commissioned to carry out certain experiments on a large scale in the Médoc, and who reported most favourably on the efficacy of the treatment of sulphate of copper as a means of destroying the phylloxera. As regards vine cultivation in Algeria, it continues, says the *Bulletin de Statistique*, to make rapid progress. The yield, in 1884, amounted to 896,000 hectolitres for an area of 50,716 hectares, while during the course of last year many new vineyards were planted, and the production amounted to 1,018,300 hectolitres, distributed as follows:—398,330 in Algiers, 261,890 in Constantine, and 358,080 in Oran.

OIL SEEDS OF EGYPT.

Several plants are grown in Egypt for the sake of their oleaginous properties, the principal being as follows:—*Sesame*, or *Semsem* (*Sesamum indicum*), is cultivated in Central Egypt on a large scale, being sown in June and harvested in autumn. The stems are pulled up bodily, and conveyed in an upright position to suitable spots; as soon as the capsules are dry they open in the sun, and shaking them suffices to dislodge the seed. The oil obtained by pressing the seeds is thin and yellow, and serves largely in cooking, though liable to rancidity; when purified it is a good illuminant. The castor-oil plant, or *Kharoûa ahmar* (*Ricinus communis*), attains the proportions of a small tree, and produces much oil, especially in Fayoum. An oil-yielding lettuce (*Khass*) is grown about Edfou, and in the southern part of the province of Thebes; when ripe, the plant is cut, dried, and threshed, the seed affording a pale yellow very sweet oil, used in cooking. An oil-yielding radish (*Symagâh*) is grown for its seed, the oil finding application in the arts. The ground nut, or *Fûl sennari* (*Arachis hypogæa*), requires a light soil into which it can thrust its seeds for maturation; the oil obtained from them may replace that of the almond, while the roasted nuts themselves are good eating, and serve instead of hazel nuts in pastries. Garden cress, or *Richâd* (*Lepidum sativum*), in Upper Egypt, affords a seed oil, while the young plants are used in salad. Mustard, or *Khardal* is similarly utilised, and colza, or *Selgâm* (*Brassica campestris*), is grown solely for its seed oil. The seeds of the safflower, flax, and cotton, are all pressed for their oil in Lower Egypt; whilst the opium poppy (*Papaver somniferum*) and the heliotrope, turnsole, or *Ayn-el-chems* (*Heliotropium europœum*), are similarly utilised in Upper Egypt.

MANUFACTURE OF BEER IN GERMANY.

The United States commercial agent at Mayence says that, according to the latest statistics, the number of breweries in the German Empire has gradually declined from 14,157 in 1872, to 10,703 in 1884, exclusive of those in Bavaria, Wurtemburg, Baden, and Alsace-Loraine, as the people of those parts of the Empire do not pay their beer taxes into the Treasury of the General Government, but to their respective States. During the year ended April, 1884, the breweries consumed 4,725,731 double centners of malt, this being equivalent to about 1,044,386,551 pounds avoirdupois, of which 457,805 consisted of barley malt, and 24,659 centners of malt surrogate, from which 619,885,853 gallons of beer were obtained. In Bavaria the amount produced in the same period was 269,839,064 gallons, in Wurtemburg, 67,844,106; in Baden, 26,850,016; and in Alsace-Lorraine, 18,113,172 gallons. The quantity of beer brewed from 1872 to 1883-84, amounted to 65 quarts per head of population in that part of Germany subject to Imperial taxation; to 262 quarts in Bavaria; 196 quarts in Wurtemburg; 76 quarts in Baden, and 56 quarts in Alsace-Lorraine. The average for the whole of the Empire, exclusive of Bremen and Hamburg, the free cities, was 93 quarts per head. The gross amount of beer tax collected, in 1883-84, by the Imperial Government was about £960,000; by Bavaria, £1,595,000;

by Wurtemburg, £365,000; by Baden, £195,000; and in Alsace-Lorraine, £92,000. During the last twelve years the average tax per hectolitre, the hectolitre being equivalent to about 22 Imperial gallons, has been 84 pfennings, or about tenpence, in that part of Germany which pays an Imperial tax; about two shillings in Bavaria; one shilling and eightpence in Wurtemburg; two shillings and fourpence in Baden, and about two shillings and twopence in Alsace-Lorraine. The entire quantity of beer consumed within the limits of the German Customs Union, during 1883-84, was 39,900,000 hectolitres, or 877,800,000 gallons, or about 93 quarts per head of population.

Correspondence.

MUSEUMS OF TRADE PATTERNS.

It is obvious that a museum of trade patterns would be of great advantage to manufacturers—equally obvious, it seems to me, that it is no one's business but the manufacturer's to provide it. Where any particular manufacture is of sufficient importance to a town or district, such town or district might, of course, be expected to lend its support to the undertaking. To draw upon the national purse for the encouragement of this or that manufacture, or of all manufactures, would be an injustice to the trades, arts, sciences, and professions not equally encouraged.

Mr. Trueman Wood alluded to the collection of patterns at the office of the Registrar, in Chancery-lane. There is another collection which deserves mention—that, namely, in the Museum at South Kensington. It is refreshing to read Mr. Wallis's remarks on the "pictorial craze" of the modern Englishman. But has not the Department done much to foster that feeling? Was not the South Kensington Museum established as a museum of industrial art; and is not a great part of it taken up with pictures, more or less worth exhibiting, but certainly out of place where they are? If a clean sweep were made of the paintings in oil and water colour at South Kensington, there would be room to extend, complete, and localise the admirable collections which at present lead a nomad existence within the walls of the Museum. If South Kensington did what it ought to do, and what it was established to do, there would be no need of Mr. Ablett's supplemental museums. The mere accumulation of patterns without selection would be worse than useless. The Department also might do much more than it does in distributing ideas of industrial art. In Continental museums you find that there are good and fairly cheap photographs to be bought of the objects exhibited. With the modern facilities in the way of "process," we ought to have, not merely occasional sheets of comparatively costly colour-printing, but permanent photographs, at a penny a piece, of all the really fine things in the Museum.

It seemed to be generally agreed, in the discussion which followed Mr. Ablett's paper, that the manufacturer did not want trade museums of patterns. It is probable that in most cases he somehow *gets* patterns of foreign goods at the earliest possible date, which naturally he keeps to himself. "Trade jealousy" has an ugly sound, but it means little more than the instinct of self-preservation. With all our registration laws, the producer has, as Mr. Ablett confesses, "very little protection." Directly a pattern is "out," or directly it promises success, it is seized upon, as though there were no such thing as morality in trade and manufacture at all. The passing of a law by which a man could really keep a pattern would do more for the art of design than any trade museum; for then a man would have an interest in bringing out a really good thing; nor would he object to exhibit it.

LEWIS F. DAY.

13, Mecklenburg-square, W.C.,
Jan. 16th, 1886.

General Notes.

POPULATION OF MILAN.—According to the latest statistics published by the Municipality of Milan, the population of that city has been rapidly increasing, and was, in 1780, 133,000 inhabitants; 1848, 195,000; 1857, 215,000; 1871, 261,000; 1881, 320,000; 1884, 349,000.

FRUIT TRADE BETWEEN ITALY AND THE UNITED STATES.—The following is taken from the official statistics, lately published, relating to the exports of oranges and lemons from Italy to the United States during the past season, 1884-85. The number of boxes shipped from the following ports was:—

	Oranges.	Lemons.
Catania ……	63,392	103,564
Messina ……	570,884	376,137
Palermo ……	404,616	1,176,154
Sorrento ……	122,583	32,686
Milazzo ……	6,186	8,204
	1,167,661	1,696,745

which were shipped by vessels belonging to the following nations:—

	Oranges.	Lemons.
England ……	986,134	1,352,412
Italy ……..	108,415	267,208
France ……	48,691	68,861
Germany……	24,421	8,264
	1,167,661	1,696,745

Night Traffic in the Suez Canal.—The experiments for traffic by night in the Suez Canal were commenced on the 1st December; they are, however, limited to ships of war and postal steamers on that portion of the canal extending from Port Said to the 54th passing station, a distance of about thirty miles. All vessels are provided with electric lamps capable of throwing a powerful light on every side.

American Exhibition, 1887.—It has been arranged that this Exhibition shall be opened on Monday, May 2, 1887, instead of May 1, 1886. The Executive Council were prepared to carry out their original intention, but have yielded to the strongly expressed opinion that it was unadvisable to hold the American Exhibition in the same year as the Colonial and Indian Exhibition.

Electric Tram-car at Berlin.—Mr. Reckenzaun's electric tram-car, which was described in the *Journal* of January 2, 1885 (vol. xxxiii., p. 160), has been introduced into Berlin. In notice of the trials given in the *Electrician* of January 15, it is stated that the car has been running daily, and that in the previous week a number of directors of different tramway companies from all parts of Germany inspected the working of the car.

Exports from Brazil.—The *Revista Commerciale* of Buenos Ayres, publishes a long article on the commerce of Brazil, and gives the following figures to show that the quantities of the principal articles of export have increased during the last four years, as is shown by the following:—

Year.	Coffee. kilogs.	Sugar. kilogs.	India-rubber. kilogs.	Tobacco. kilogs.
1880-81	219,519,022	161,258,398	6,722,638	19,900,188
1881-82	243,888,010	246,669,276	6,840,210	23,646,845
1882-83	232,228,517	223,865,220	6,781,724	21,773,516
1883-84	224,589,309	235,317,240	8,111,764	23,435,512

The Highest Chimney in the World.—The highest chimney in the world is said to be that recently completed at the lead mines of Mechernich. It is 134 metres (439' 6") high, was commenced in 1884, and was carried up 23 metres before the frost set in; building was again resumed on the 14th of last April, and it was completed last September. The foundation, which is of dressed stone, is square, measuring 11 metres (33 feet) on each side, and is 3·50 metres (11' 6") deep; the base is also square, and is carried up 10 metres (33 feet) above the ground. The chimney-stack is of circular section, 7·50 metres (24' 6") diameter at the bottom, and tapering to 3·50 metres diameter (11' 6") at the top, and is 120·50 metres (395 feet) high.

Poultry Breeding in France.—*L'Illustration* gives the following statistics relating to poultry in France; it appears from these that the poultry yards in that country represent a very large capital. The number of fowls is estimated at 45,000,000, which, valued at 2½ francs each on the average, would amount to 112,500,000 of francs. The number of laying hens is taken at 34,000,000, and taking the number of eggs laid by each at an average of 90 yearly, the total production of eggs in France would not fall short of 3,000,000,000, which, at an average of 5 cents each, would amount to 150,000,000 francs. Of this number it is calculated that 100,000,000 of eggs are hatched, of which 10,000,000 die as young chickens, 10,000,000 serve for reproduction, whilst 80,000,000 of chickens serve for food, which, valued at 1½ francs each, would represent 120,000,000 francs. To these figures must be added an extra value of 6,000,000 for capons. Altogether, the value of poultry and eggs produced in France may be taken at 300,000,000 francs.

MEETINGS OF THE SOCIETY.

Ordinary Meetings.

Wednesday evenings, at Eight o'clock:—

The following Dates have been fixed.

January 27.—"Machinery in Mines." By Henry Davey. Sir Frederick Bramwell, F.R.S., will preside.

February 3.—"Artistic Bronze Casting." By George Simonds. Sir Philip Cunliffe-Owen, K.C.M.G., C.B., C.I.E., will preside.

February 10.—"The National Exhibition at Buda-Pest, and the Mineral Resources of India." By Bennett H. Brough.

February 17.—"Some Points in Electrical Distribution." By Professor George Forbes.

February 24.—"The employment of Autographic Records in Testing Materials." By Prof. W. C. Unwin.

March 3.—"Calculating Machines." By C. V. Boys.

March 10.—"The Experiments with Lighthouse Illuminants at the South Foreland." By Price Edwards. Lord Rayleigh, Secretary of the Royal Society, will preside.

Dates to be hereafter Announced:—

"The Treatment of Sewage." By Dr. C. Meymott Tidy.

"Domestic Electric Lighting." By W. H. Preece, F.R.S.

Foreign and Colonial Section.

Tuesday evenings, at Eight o'clock:—

January 26.—"The Importance of a National Scheme of Emigration for the best interests of British Commerce." By Arnold White.

February 16.—"The Aspect of Affairs in the Interior of South Africa." By Major-General Sir Charles Warren, R.E., G.C.M.G.

March 23.—"The Commercial Progress of New South Wales." By Edward Combes, C.M.G.

March 2; April 13; May 18.

APPLIED CHEMISTRY AND PHYSICS SECTION.

Thursday evenings, at Eight o'clock:—

JANUARY 28.—"Magnetism of Ships and the Mariner's Compass." By WM. BOTTOMLEY, Jun.

FEBRUARY 11.—

FEBRUARY 25.—"Photography and the Spectroscope in their Application to Chemical Analysis." By Professor W. N. HARTLEY, F.R.S.

MARCH 11.—

APRIL 8.—

MAY 13.—"The Scientific Development of the Coal Tar Colour Industry." By Professor R. MELDOLA, F.C.S.

INDIAN SECTION.

Friday evenings, at Eight o'clock:—

JANUARY 22.—"Burma; the Eastern Country and the Race of the Brahmas." By J. GEORGE SCOTT (Shway Yoe). The Hon. Sir ASHLEY EDEN, K.C.S.I., will preside.

FEBRUARY 19.—"Historical and Recent Famines in India." By F. C. DANVERS, F.S.S., Registrar and Superintendent of Records, India-office. J. M. MACLEAN, M.P., will preside.

MARCH 19.—"Experiences on the Afghan Frontier." By WILLIAM SIMPSON. Col. HENRY YULE, C.B., will preside.

April 2; May 7, 21.

The above dates are liable to alteration.

CANTOR LECTURES.

The Second Course will be on "Friction" By Prof. H. S. HELE SHAW.

Lecture II.—January 25.—The Friction of Fluids.

Lecture III.—February 1.—The Mechanical Applications of Friction.

Lecture IV.—February 8.—The Methods of Reducing Friction.

ADDITIONAL LECTURES.

"Japanese Art Work." BY ERNEST HART.

Lecture I.—May 4.—Japanese Metal Work.

Lecture II.—May 11.—Japanese Porcelain and Pottery.

Lecture III.—May 18.—Japanese Picture Books and Drawings.

MEETINGS FOR THE ENSUING WEEK.

MONDAY, JAN. 25...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. (Cantor Lectures.) Prof. H. S. Hele Shaw, "Friction." (Lecture II.)

Inventors' Institute, Lonsdale-chambers, Chancery-lane, E.C., 8 p.m. Mr. W. Johnson, "Brick-making Machinery; Bricks and their Manufacture."

Geographical, University of London, Burlington-gardens, W., 8½ p.m. Mr. W. R. Carles, "A Recent Journey in Corea."

Actuaries, The Quadrangle, King's College, W.C., 7 p.m.

Surveyors, 12, Great George-street, S.W., 8 p.m. Adjourned discussion on "The Copyhold Enfranchisement Bill, 1884-85."

Medical, 11, Chandos-street, W., 8½ p.m.

London Institution, Finsbury-circus, E.C., 5 p.m., Mr. Frederic Harrison, "Paris as a Historical City."

TUESDAY, JAN. 26...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. (Foreign and Colonial Section.) Mr. Arnold White, "The Importance of a National Scheme of Emigration for the best Interests of British Commerce."

Royal Institution, Albemarle-street, W., 3 p.m. Dr. R. Stuart Poole, "Naucratis." (Lecture III.) "The Egyptian Sources of Greek Art."

Medical and Chirugical, 53, Berners-street, Oxford-street, W., 8½ p.m.

Civil Engineers, 25, Great George-street, S.W., 8 p m. Mr. Stromeyer, "The Injurious Effect of a Blue Heat on Steel and Iron."

Anthropological, 4, St. Martin's-place, W.C, 8 p.m.

East India Association, Council-room, Exeter-hall, Strand, W.C., 3 p.m. Mr. Henry Stanley Newman "Water Storage and Canals in India: How far they are Preventive of Famine."

WEDNESDAY, JAN. 27...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. Mr. Henry Davey, "Machinery in Mines."

Geological, Burlington-house, W., 8 p.m.

Institute of Patent Agents, 63, Chancery-lane, W.C., 7½ p.m. Resumed discussion on Mr. Ernest de Pass's paper on "The Articles of the International Convention, which deal with the question of Patents."

Royal Society of Literature, 4, St. Martin's-place, W.C., 8 p.m.

Civil and Mechanical Engineers, 7, Westminster-chambers, S.W., 7 p.m. Mr. R. Harkess Twigg, "The Safety of Life and Property at Sea."

United Service Institute, Whitehall-yard, S.W., 3 p.m. Major M. T. Sale, "Land Mines."

THURSDAY, JAN. 28...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. (Applied Chemistry and Physics Section.) Mr. William Bottomley, jun., "The Magnetism of Ships and the Mariner's Compass."

Royal, Burlington-house, W., 4½ p.m.

Antiquaries, Burlington-house, W., 8½ p m.

London Institution, Finsbury-circus, E.C., 5 p.m. Prof. John Perry, "Telpherage, or the Automatic Sending of Things by Electricity."

Royal Institution, Albemarle-street, W., 3 p.m. Prof. W. Chandler Roberts Austen, "Metals as affected by Small Quantities of Impurities." (Lecture I.)

Telegraphic Engineers and Electricians, 25, Great George-street, S.W., 8 p.m. Inaugural Address by the President, Professor D. E. Hughes, on "Self-Induction on an Electric Current in Relation to the Nature and Form of its Conductor."

FRIDAY, JAN. 29...Royal Institution, Albemarle-street, W., 8 p.m. Weekly Meeting, 9 p.m. Sir William Thomson, "Capillary Attraction."

United Service Institute, Whitehall-yard, S.W., 3 p.m. Captain H. T. Allatt, "The Use of Pigeons as Messengers in Wars, and the Military Pigeon System of Europe."

Civil Engineers, 25, Great George-street, S.W., 7½ p m. (Students' Meeting.) Mr. Llewelyn B. Atkinson, "Electrical Measuring-Instruments."

Browning, University College, W.C., 8 p.m. 1. Mr. J. B. Bury, "Aristophanes' Apology." 2. Paper by Mr. L. S. Outram.

SATURDAY, JAN. 30....Royal Institution, Albemarle-street, W., 3 p.m. Prof. A. Geikie, "The History of Volcanic Action in the British Isles." (Lecture I).

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FRIDAY, JANUARY 29, 1886.

All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

NOTICES.

CANTOR LECTURES.

The second lecture of the course on "Friction" was delivered on Monday evening, 18th inst., the subject being the friction of fluids.

The lectures will be printed in the *Journal* during the summer recess.

Proceedings of the Society.

INDIAN SECTION.

Friday, January 22nd, 1886; the Hon. Sir Ashley Eden, K.C.S.I., in the chair.

The paper read was—

BURMA; THE EASTERN COUNTRY AND THE RACE OF THE BRAHMAS.

By J. George Scott (Shway Yoe).

The Burmese system of the universe is very orderly, but it conflicts somewhat with the theories of western men of science. In the centre stands Mount Meru, shaped like a cask floating end upwards, half above the ocean, half below. It rests on three feet, huge rubies and carbuncles. On its slopes are the six seats of Devas, the beings who by good works and incessant meditation have risen above man's estate on the path to Nirvana. Above the mountain in the empyrean are the sixteen seats of the Brahmas, the Perfect, who live in a state of sublime contemplation. Down below are the eight great hells and the numberless smaller ones. Round Mount Meru extends the vast Thamohddaya ocean, girdled in by the seven ranges of the Sekyawala hills, with seven seas interposed. In the sea round Mount Meru are four great islands, the northern, eastern, southern, and western, and each of these has five hundred small islands round about it. The race of man inhabits the Southern Island. The Burmese, the Chinese, and Indo-Chinese, and the Indians, people the mainland, and the English and other foreigners live in the small islands.

The eastern, western, and northern islands are very pleasant to live in, but especially the northern. It is a regular land of Cockayne. Gorgeous dresses hang ready made from the trees. Dainty meats of all kinds grow up and cook themselves. But still they are not happy. Like the eastern and western islanders, they are always reborn in the same place, and cannot raise themselves. It is only in the Southern Island that Buddhas appear to teach the law, and free the people from constant deaths and reappearances. Only there can man rise in the scale of existence until he finally frees himself from passion, and sorrow, and the trammels of existence, and sinks into the bliss of Nirvana. Therefore, the pious have called the Southern Island the ferry to Nirvana.

The whole universe is destroyed once in an Asankya,

> "which is the tale
> Of all the drops that in ten thousand years
> Would fall on all the worlds by daily rain."

The present universe, called Badda, has a little over four quadrillion years to run. It was first peopled by Brahmas, who came down from the highest heavens and degenerated. Of these Brahmas the Burmese are the direct descendants; they call themselves Bam-ma, which is merely a mutilated form of Byam-ma, the Burmese form of Brahma. They were celestial beings once, and hope to be so again.

The particular part of the southern island they inhabit is called the Ashay Pyee, the Eastern Country. The Chinese live east of them, it is true; but the Chinese are "elder brothers" and Buddhists, though very bad ones. India is called the Middle Country. The east is the place of honour, for it was from the east that the Buddha came. The name has, therefore, the signification of the "foremost country," the one that is superior to all others, the country ruled over by the King of the Umbrella-bearing Chiefs, the

Arbiter of Existence, the great Lord of Righteousness, as the King of Burma was called, among other titles.

Now that we have got the Burmese view of themselves and their country, we may turn to more matter-of-fact statements about Burma, the more readily seeing that there is only one "Burma" now. The distinction between "Upper" and "Lower" Burma is simply a provincial, not a governmental, matter. All the early history, dating from the 7th or 8th century before our era, we may dismiss as more or less imaginative, a kind of Arabian Nights of a somewhat truculent kind. But already in the time of Ser Marco Polo the Burmese were a formidable power. The old Venetian writes:—

> "Now there was (in A.D. 1272) a certain King of Mien (the Chinese name for Burma) and Bengala who was a very puissant prince, with much territory, and treasure, and people; and he was not yet subject to the great Khan (Emperor of China), though it was not long after that the latter conquered him, and took from him both kingdoms which I have named. And it came to pass when the King of Mien and Bengala heard that the host of the great Khan was at Vochan (the present Yung-Chang), he said to himself that it behoved him to go against them with so great a force as would ensure his cutting off the whole of them. So this king prepared a great force and ammunitions of war, and he had 2,000 great elephants, on each of which was set a tower of timber, well bound and strong, and carrying twelve to sixteen fighting men. When the king had completed these great preparations to fight the Tartars, he tarried not, but marched straight against them. And after marching without meeting with anything worth mentioning, they arrived within three days of the great Khan's host, which was then at Vochan in Zardandan, so there he pitched his camp. And when the captain of the Tartar host, Nasaradin, had certain news of the aforesaid king, he waxed uneasy, as he had with him but 12,000 horsemen. However, he advanced to receive the enemy in the plain of Vochan, and when the king's army had arrived in the plain, and was within a mile of the enemy, he caused all the elephants to be ordered for battle, and began to advance. The horses of the Tartars took so much fright at the sight of the elephants, that they would not face the foe. And when the Tartars perceived how the case stood, they were in great wrath. But their captain acted like a wise leader, for he ordered every man to dismount, and to tie his horse to a tree, and then to take their bows. They did as he bade them, and plied their bows so stoutly on the advancing elephants, that in a short space they had wounded or slew the greatest part of them. So when the elephants felt the smart of the arrows that pelted them like rain, they turned and fled into the woods, dashing their castles against the trees, and bruising the warriors. So when the Tartars saw that the elephants had turned tail, they got to horse, and at once charged the enemy, and then the battle raged furiously, and when they had continued fighting till midday, the king's troops would stand against the Tartars no longer, but felt they were defeated, and turned and fled."

Immediately after this came the first Chinese invasion of Burma. The king retreated on the sea coast, and his capital, Pagán on the Irrawaddy, was sacked. The Chinese, however, after a time, retired over the hills again. After this there were periodic invasions from China, most of them unsuccessful, but the result was that Burma was split up into separate kingdoms—Pegu, the Talaing kingdom, Arakan, and Upper Burma, the country of the Burmese proper, with occasional independent kings in particular districts such as Toung-oo.

It is only after the Portuguese navigators entered the eastern seas that any real notion of the actual state of Burma can be formed. Malacca was captured by Albuquerque in 1511, and at that time it would seem that the country now known as Burma was divided into four kingdoms, Arakan, Pegu, Burma, and Ava, each having its own king and quarrelling with its neighbours. One of these, Buyin-Gyee Noung Zaw, or Branginoco, as he is called by the old chroniclers, engaged a number of Portuguese adventurers, and with their aid subdued his neighbours, and even invaded Siam. He was murdered, as most sovereigns were in those days, and succeeding kings in all the kingdoms round about in succession engaged Portuguese soldiers of fortune, and invaded and ravaged and slaughtered vigourously.

At last, in 1600, the King of Arakan gave the port of Syriam, close to Rangoon, to Philip de Brito, better known as Nicote, one of the most notable of these soldiers of fortune. This seems to have been the first concession of land in Burma to any European power, and it speedily excited a desire for more. Nicote went off to Goa and obtained six ships of war to effect the conquest of Pegu. This he partially succeeded in doing, and it was only after thirteen years nearly continuous fighting that Syriam was taken and Nicote impaled. About the same time another adventurer, Gonsalves, a Spaniard, established himself on the island of Sunda in the Sunderbunds, and waged war on Moguls and Arakanese alike. But he and his followers were mere pirates, and, at the price of vassalage to the King of Portugal, the Arakanese monarch received assistance from the Viceroy of Goa, and extirpated them. But the suzerainty was only slightly acknowledged. The other potentates made Portuguese alliances also, and constant wars went on without advantage to any one.

Our connection with Burma began about the same time, and was certainly more peaceful. Mr. Ralph Fitch seems to have been the first Englishman who visited Burma. He was there in 1586, and his objects were more commercial than warlike. In his narrative, he tells us that the city of Pegu was "strong, very fair, with walls of stone, and great ditches round about it." It had twenty gates, was built square, and the moat was full of crocodiles, which reminds one of the way in which the kings of Annam defended their treasury. The town was very rich and populous, and, notwithstanding the constant wars, did much trade. Opium is specially mentioned; so that we are hardly so guilty in that matter as some people would have us believe. Masulipatam sent painted cloth, and Bengal its "woven webs, so fine twelve folds hide not a modest face." Cotton, sandal, porcelain, and other wares came from China, camphor from Borneo, pepper from Atchín in Sumatra. European goods were sent from Mecca—woollen cloths, velvets, scarlets, and the like. The exports were mostly metals, gold and silver, sapphires and rubies, musk, lacquer, wax, rice, and sugar. Altogether, Ralph Fitch's account is a relief after the continual massacreings and impalings of the Portuguese.

The result was considerable trade with Burma from both England and Holland. In the early part of the 17th century both English and Dutch had factories at Bhamô, north of Mandalay. The Dutch, however, quarrelled with the Burmese, and threatened to call in the Chinese to their aid. The Burmese then, as now, were little inclined to yield to threats, and they turned the Dutch out of the country, and the English along with them. The Dutch were never re-admitted, and it was many years before we were either.

At last, however, in 1697, a Mr. Thomas Bowyer arrived in Syriam, and a factory was established, only to be burnt down because Mr. Smart, the East India Company's agent of the time, mixed himself up in the quarrels of the Burmese and the Talaings. This was in 1743, and led to the withdrawal of the establishment about forty-six years after it had been founded.

Meanwhile the turn of fortune's wheel had brought the Peguans to the top. They invaded Burma, sacked and burnt Ava, and carried the king off as a prisoner, and after keeping him in imprisonment some time, put him in a red sack and drowned him in the river. Notwithstanding that this was strictly in accordance with precedent, the Burmese were so enraged that they rose and massacred the Talaing garrisons, and eventually gathering round a simple hunter of the small village of Myouk-myo, or Moht-sho-bo, eighty miles north-west of Ava, not only expelled the Talaings, but pursued them into their own country and conquered Pegu and Tenasserim and eventually Arakan. At last, in 1757, he built a palace at Dagohn and called the place Yan-gohn—the war is finished. This is Rangoon, the present capital of Burma, for we are hardly likely to shift the seat of government to Mandalay, and the warlike hunter was Aloung-payah, or Alompra as he is usually called, the founder of the last Burmese dynasty.

He united the whole country under his rule, and as there was now some chance of making a treaty which would not be upset by local disturbances, both the East India Company and Dupleix, the Governor-General of French India were soon busy asking for favours. The king gave Negrais Island, also called Hain-gyee, on the Arakan coast, to the British, in perpetuity, and allowed the French to keep on a factory at Syriam. Neither, however, was destined to last long. Alompra was informed that they were intriguing with the Peguans, and about the same time, in 1759, the French were killed or carried prisoners to Ava, and the English on Hain-gyee were massacred, all but a few who were able to escape to the ships in the offing. Captain Alves was sent to demand satisfaction, for there were some soldiers among the victims, but when he reached Ava, he found that Alompra was dead and the city in rebellion. The great king died on an expedition against Siam. He had demanded a daughter of the royal house in marriage, and when she was refused, marched off to fetch her. But he died before he could do it, after seven years' reign.

No satisfaction was got for the Negrais massacre, notwithstanding that three years later Sin-Byoo-Shin (the lord of the white elephant), the second son of Alompra, established himself firmly on the throne. We had more serious matters on hand in India then. Sin-Byoo-Shin reigned thirteen years, and during all that time he was fighting. He repulsed four invasions of the Chinese, who wanted to exact tribute. He invaded Siam, destroyed Ayuthia, the then capital, and took most of the royal family prisoners. He asserted his authority over the Shan states, as far as the Mekong, and he over-ran and practically annexed Munnipur. After his death there was a great deal of quarrelling over the succession, and two kings and any number of conspiring princes were sewn up in red sacks and thrown into the Irrawaddy. At last, however, in 1782, Bo-daw Payah (the sainted royal grandfather) succeeded, and with him, in 1795, we first came into direct political intercourse. Captain Symes was sent by Sir John Shore, the Governor-General of India, on an embassy to Ava for the purpose of strengthening our commercial relations and preventing the French from gaining a footing in the country. In addition to this the Burmese, who had meanwhile annexed Arakan, had been making hostile demonstrations on our Chittagong frontier. Symes' mission was not very successful, but he obtained a royal order, granting permission for the establishment of a British residency at Rangoon. Captain Hiram Cox was sent to act as agent in 1796, but he was subjected to so many indignities, both in Rangoon and Ava, that he left for Calcutta again. But there was much unpleasantness between English merchant shippers and the Rangoon native authorities, so in 1802, Captain Symes was again sent to the Burmese capital by Lord Wellesley. The mission was a grand one, and Symes was ordered to seek a treaty of alliance and to demand the recession of Negrais Island, or compensating commercial advantages. The fate of Martin da Costa Falcom, the Portuguese Ambassador of the 17th century, awaited him. The mission was an utter failure. The gallant captain never had a proper audience. He was persistently and elaborately insulted, and eventually went back to Bengal without settling anything. But the Indian Government was not daunted, and many efforts at negotiation were made afterwards. The story is, however, not a pleasant one, and I only refer to the matter to show that French intrigue is no new matter in Burma, and that Burmese officials have been consistently overbearing and contemptuous, while we, through our representatives, have been patient and long-suffering. The insolent treatment of our envoys was not our only cause of complaint. Wherever Burmese territory touched British there was aggression, and no redress was to be had. The king demanded the surrender of refugees who had fled into our territory for protection, and when this was refused, called upon the Governor-General to cede Chittagong, Dacca, and Murshidabad.

There could be only one end to this, and it came in 1824. The Burmese drove a Sepoy garrison out of Supari island at the mouth of the Naaf river, and we declared war. At this time the empire of Burma was one of the most extensive, as well as the most formidable, powers in Asia. Besides Burma proper, and the provinces of Pegu, Arakan, and Tenasserim, it embraced the principality of Mogoung, the northern Shan and Kachyen States, Assam, Cachar, Munnipur, and had as tributaries all the Shan chieftains as far east as the Mékong river. It had a thousand miles of sea-board, and years of constant fighting had made a naturally brave and warlike people so confident in their invincibility that they listened complacently to the order of the day issued, calling upon them to march to England. The first fighting began in Sylhet and Assam, and there our troops were held in check for some time, while in Chittagong they were routed by a superior force of Burmese. Calcutta was in a state of panic, and the Europeans formed themselves into a militia. Then, however, the capture of Rangoon by a British force, and the defeat of the Burmese generals there, caused a diversion, and Assam and Chittagong were evacuated by the Burmese. It is not necessary to give an account of the war. The British force numbered only a little over 12,000, of whom about 7,000 belonging to native regiments, but they were enough, notwithstanding the determination with which the Burmese fought on several occasions, especially under their great general, Mahah Bundoola. Eventually, in 1826, after a battle at Pagán, when the English troops under Sir Archibald Campbell were at Yandabo, only forty-five miles from Ava, the king gave in. Arakan, Tenasserim, and a part of Martaban, were ceded to us. Cachar, Jyntea, and Assam were given up, and Munnipur was declared independent and under British protection. The terms were cheap, for the country was entirely at our mercy. The expedition had been begun at the worst time of year, and Burmese duplicity delayed our troops several times in most feverish jungles. The consequence was that the losses of our troops were enormous. During the two years of the war the mortality amounted to 72½ per cent. of the men engaged, and of these only 5 per cent. were killed in action. This has never been forgotten, and to this day one hears of the pestilential swamps and the dreadful climate of Burma. As a matter of fact, it is as healthy, if not more healthy, than most parts of India.

The Burmese had got a lesson, but they did not profit much by it. The king and his governors were as insolent and contemptuous as ever. Major Burney stayed for some years as Resident at Ava, but the insults which were offered became so constant and unendurable, that he asked and obtained permission from the Indian Government to withdraw, and his example was followed by several successors. The state of affairs cannot be better described than in Lord Dalhousie's words:—

> "Of all the Eastern natives with which the Government of India has had to do, the Burmese are the most arrogant and over-bearing. During the years since the (1826) treaty had been concluded, they had treated it with disregard, and had been allowed to disregard it with impunity. They had been permitted to 'worry away' our envoys by petty annoyances, and their insolence had even been tolerated, when at last they vexed our commercial agent at Rangoon into silent departure from their port. Inflated by such indirect successes as these, the Burmese had assumed again the tone they used before the war of 1825. On more than one occasion they had threatened a recommencement of hostilities against us, and always at the most untoward time. Every effort was made to obtain reparation by friendly means. The reparation was no more than compensation for the actual loss incurred, but every effort was in vain. Our demands were evaded, our officers were insulted. The warnings which we gave were treated with disregard, and the period of grace which we allowed was employed by the Burmese in strengthening their fortifications and in making every preparation for resistance."

It is as well to insist on this, because those good people who always maintain that the man who fights is in the wrong, declare that we had not sufficient grounds for the second Burmese War of 1852. It began suddenly, and it was finished drastically. We drove the Burmese troops out of Martaban, Rangoon, Bassein, Pegu, Toungoo, and Prome, the townspeople everywhere receiving us as friends. From this last town we might have advanced by steam on Ava, as General Prendergast did last month. But Lord Dalhousie determined to rest content with the province of Pegu, in compensation for the past and for better security in the future. No treaty was entered into with the king, who indeed had been deposed by his own subjects. The country was simply taken possession of, and a proclamation to that effect was issued and peace declared in 1853. The later history I need not trouble you with. Burmese insolence only grew with our forbearance and clemency. We might have annexed in 1826, or in 1852; we have done so in 1886. There was no other possible end to the question.

The country which hitherto we have known as British Burma has now been doubled in size by the annexation of Burma Proper, an area nearly equal to that of the United Kingdom. It will be some time before the boundaries on the eastern side are fixed; that will have to be done by arrangement with China, with whom we shall no doubt have to share the management of the numerous Shan and Kachyen hill-chieftains; a delicate matter, which nothing but just, and at the same time firm, handling will carry through successfully. But that we need not trouble ourselves with here. It will be enough to say that, roughly speaking, our new province consists simply of the valley of the Irrawaddy river, walled in by hilly table-lands and mountain ranges (varying from five thousand feet on the east and west to eighteen thousand or more on the north) on every side except the south, where nothing but a parallel of latitude along which masonry pillars, from two to ten miles distant from one another, and often hidden in the jungle, marked the old boundary line. The character of the country is much the same as that of Lower Burma. There are rich alluvial plains, intersected by barren rolling ground of no great elevation and lines of hills, spurs from the main ranges to east and west, joining the watersheds between the different tributaries of the Irrawaddy. There is very much more forest and very much less cultivation than in our sea-board provinces, the natural results of misrule. Roads there are practically none, the tracks which represent them are mere lines where the jungle has been cut away. When a Burman makes a wheel for his bullock cart he cuts it out of a solid slab of wood, leaves it square, or with imperfectly blunted corners, and trusts to time to round it for him. Even good roads would not remain long so under such traffic. No census of the country has ever been taken, and the number of our new subjects is therefore purely conjectural, but it probably does not exceed two millions, if indeed it reaches that figure. Our great want in

Burma—greater now than ever—is population. About half the area of our three lower provinces is cultivable, but up to now, only about 4,000 square miles, not quite an eighth of this, are under cultivation. In 1884, Mr. Bernard estimated the population at a little over 4,000,000, an increase of something like 40 per cent. in 12 years, but still a total far short of the wants of the provinces. But the acquisition of Upper Burma, though it will bring down the population per square mile, will soon lead to the arrival of new immigrants. With a strong and good government in the interior, Chinamen from Yun-nan and Ssu-ch'uen, and Shans from the border hills will flock into the plains, and Shans, like Chinamen, are born farmers and gardeners. The problem is now solved. Indian immigration has been an utter failure. The Burmese detested and despised the ryots brought over, and the poor Madrassis themselves seemed incapable of doing anything. Now that the Chinamen can come on their own legs instead of having to make the long sea-voyage round by Singapore, and the Straits, they will not delay to flock into the fertile lowlands of Burma, where the soil only requires to be scratched to bring forth abundant crops. Our lower provinces, as well as the new one, will profit by the disappearance of the buffer state.

From the brief glance we had of the history of Burma, especially of the connections we have had with the Burmese, it might be supposed that they are an entirely objectionable race. Nothing could be more unjust with regard to the people at large. Their rulers have been bad enough, aud indeed a Burman in authority, even under our control in the lower provinces, is not always the most amiable of personages. To mention a Burmese policeman to an Anglo-Burman, or even to a Burman for the matter of that, has much the same effect as squirting hot water into his ears. He becomes voluble and abusive on the spot. Conceit is the greatest fault of the Burman. In some respects it is not altogether a bad quality, but it entirely depends upon your point of view with regard to the person who exhibits it. The Burmese kings exhibited it in most grandiose fashion. The first Burmese war was described in the following fashion:—

"The white strangers from the west fastened a quarrel upon the Lord of the Golden Palace. They landed at Rangoon, took that place and Prome; and were permitted to advance as far as Yandabo; for the king, from motives of piety and regard to life, made no effort whatever to oppose them. The strangers had spent vast sums of money on the enterprise; and by the time they reached Yandabo their resources were exhausted, and they were in great distress. They petitioned the king, who in his clemency and generosity sent them large sums of money to pay their expenses back, and ordered them out of the country."

The strangers, however, have stayed ever since in the provinces of Arakan and Tenasserim, and they were rude enough to call the money for their expenses an indemnity. Shortly before the above declaration the king had sent a note to Sir Archibald Campbell representing that "it was contrary to his religious principles and the constitution of the Empire to make any cession of territory, and he was bound to preserve its integrity." The king was referred to as the "Emperor of emperors against whose imperial majesty if any shall be so foolish as to imagine anything, it shall be happy for them to die and be consumed; the lord of great charity and help of all nations; the lord esteemed for happiness; the lord of all riches, of elephants and horses, and all good blessings; the lord of high-built palaces of gold; the great and most powerful emperor in this life, the soles of whose feet are gilt, and set upon the heads of all people."

The Burmese *Royal Chronicle of Kings* enumerates 587,000 and some odd hundreds of these distinguished personages. Age did not "stale their infinite variety," but on the whole, it is a matter of congratulation that the world has done with them. The founder of the dynasty of which King Theebaw was the last representative, was a very favourable specimen. Aloung Payah stood 5 ft. 11 in., a great height for a Burman, and was of a very athletic build. He was fighting all his life, and therefore had no time for the simple massacres which his descendants indulged in. But he had a right royal opinion of himself. A Captain Baker, the commander of an East Indiaman, was sent by the Company to enter into relations with him. He brought the king a present of a few chests of gunpowder, a couple of muskets, a gilt looking-glass, some lavender water, and some red earth in bags, and offered him the assistance of the Company. The Captain evidently looked upon Aloung Payah as little better than a savage, and was somewhat astonished at the king's defiant laughter, and the self-confidence of his reply:—

"Have I asked, or do I want any assistance to reduce my enemies to subjection? Let none conceive such an opinion! Have I not in three years time extended my conquests three months' journey in every quarter without the help of cannons or muskets. Nay, I have with bludgeons only opposed and defeated these Peguans who destroyed the capital of this kingdom, and took the prince prisoner; and a month hence I intend to go with a great force to Dagohn (Rangoon), when I will advance to the walls of Pegu, blockade and starve them out of it, which is the last town I have now to take to complete my conquest, and then I will go in quest of Bournou (the French governor of Syriam, whom he afterwards did put to death). Captain, see this sword; it is now three years since it has been constantly exercised in chastising my enemies; it is indeed almost blunt with use; but it shall be continued to the same till they are utterly dispersed. Do not talk of assistance. I require none. The Peguans I can wipe away as thus (drawing the palm of one hand over the other). See these arms and this thigh (drawing his loose coat-sleeve up to the arm-pit, and lifting his waist-cloth so as to display a brawny tattooed leg); amongst a thousand you cannot see my match. I can crush a hundred such as the King of Pegu."

He also announced that he intended seeking the French out in Madras, and that if a nine-pounder shot were to hit him, it could do him no harm, with a good deal more to the same effect. But he, at any rate, was a great commander. His successors had all his arrogance without his abilities. One of them goes by the name of the drunkard, or fisherman king, both pastimes, fishing as well as drinking, being abhorred by good Buddhists. Another announced that he was the fifth Buddha who is to appear in this world-cycle. The monks refused to believe it, so he cut the heads off a few thousand of them, and commenced building the Mingohn pagoda, not far from Mandalay which, even in its present unfinished state, and split as it is from top to bottom by an earthquake, is the largest mass of brick work in the world. After him several of the line were subject to fits of insanity, but even in their madness they did not commit such atrocities as when they thought the matter calmly out. Tharrawaddy had a celestial spear which he always kept by him, and occasionally used to spit a courtier, and it was in his time that the idea sprang up that the ordinary amusement of kings of Burma was to sit at their parlour window and shoot their subjects as they passed by. His son Moung Lohn, the "old king" as he is called in Burma, King Theebaw's father, was much the best king the country ever had. He was very pious, did many good works, and was particularly fond of his title "Convener of the fifth great synod;" but even in his time there were sudden deaths, even of his own sons. The king would say emphatically "I don't want to see that man any more," and he did not. The man died of "official colic" within a few hours.

Of King Theebaw very little need be said. He was a weak creature, entirely under the control of his harridan queen and her mother. The latter was described the other day as "the ordinary type of old woman." Happily, this is a libel. Ordinary old women, even in Burma, do not have their step-sons and daughters and their coadjutor or sister-wives killed by the half-dozen. That was the point about King Theebaw that his subjects did not like. They did not mind the massacres, they were quite proper and sanctioned by old custom, but that he should have only one wife seemed to them undignified and weakly in the extreme. By the actual constitution of the country he ought to have had four—the queens of the north, south, east, and west palaces—and as many more "inferior" wives as he cared for. The pious and enlightened monarch, his father, had 53 recognised wives, besides an indefinite number of handmaidens. By the wives he had 110 children—48 sons and 62 daughters. The children of the handmaidens were not counted, partly because they were not worth killing in the event of a disputed succession. Careful statisticians aver that the orthodox old gentleman averaged seven children a year. Against this record Theebaw could only show five children in five years, and three of these were dead. Such an unkingly state of things seemed to the Burmese people in the highest degree indecorous.

With kings of the character we have seen, it is not to be wondered at that the ministers and officials of lower rank were not very estimable people. This was not because there was no system of administration. On the contrary, the governmental institutions were ancient, well developed, and elaborate down to the minutest details. The number, rank, and functions of the ministers were strictly defined by precedent, and they were supposed to be appointed for special abilities. There is no hereditary rank out of the royal blood, in Burma any more than there is in China or in any of the Indo-Chinese countries. Any one might become a minister, and, indeed, instances in which men of the lowest rank, and even Coolies, have risen to the highes posts, have been far from uncommon. But it was much easier to fall than to rise, and as everyone's position depended upon the king, the country suffered just as much as if no constitution existed at all. Therefore a Burmese minister never did anything but take the utmost care that he was neither beheaded, tortured, nor dismissed. All that he ever accomplished in the way of forming a policy was to suggest that the Lord of the Golden Throne might like such and such a thing done. But even so much as that was only ventured upon by extremely conscientious men, or by personal favourites. As for the ordinary run of officials, when they were questioned about their departments, they gathered or guessed from the questions, what was expected to be done, and then declared that it was done, and afterwards proceeded to do it.

Everyone was prepared—and was very often called upon—to do everything, to advise on matters of State, politics, finance, or revenue; to try a case, civil or criminal; direct military or naval operations (from an elephant on the river-bank), or superintend the building of a royal pagoda. The assemblage of the first class of ministers was Cabinet, House of Legislature, and Supreme Court of Justice rolled in one, and there was no appeal from it, unless the king changed his mind.

This was not a very satisfactory way of administering the country, and the way in which the officials drew their pay was still less so. Each officer had given to him a province, district, or town to govern for the king's and his own benefit. From this appointment he got his territorial title and his living. He was Myo-sah, or "town-eater," of such and such a place. Most of these devourers of the people were non-resident, and had to appoint deputies, and these deputies also drew their salaries by fleecing the people. The division of the country for the collection of the revenue was identical with that for administrative purposes, and the several duties were carried on by the same persons with the same assistants. The one man was civil administrator, judge, colonel of the local militia, and revenue collector for his locality, whether province, circle, or simple village. The fixed revenue demanded by the Myo-sah, whether prince of the blood royal, minister, maid of honour, royal spittoon bearer, coxswain of a despatch boat, or lord white elephant, was remitted to Mandalay by the deputy-lieutenant of the province, together with a certain overplus for the Myo-sah's secretary, clerk, and treasurer. The more a man cultivated, the more grievously was he squeezed, so that all enterprise and industry was long ago crushed out of the life of the Upper Burman.

It is not at all wonderful, therefore, that the natives of the country we have just annexed were somewhat soured in their disposition. Years of grinding oppression changed courage into something like ferocity, and open-heartedness into gloom and suspicion. Nevertheless, the rapidity with which one of King Theebaw's subjects assimilated his ways to those of our seaboard provinces showed that nothing was wanted but changed conditions of life to make a light-hearted creature of him. It was not easy for him to cross the frontier, for all the outlets were well guarded, and the relations of any man who was known to have settled in the lower provinces were put to death; but the number that steadily every year came to establish themselves in Pegu was quite sufficient to show that the settlement of our new possession will be neither a long, nor a troublesome matter. The arrival of our troops in the country was marked by a most favourable omen. During the advance there was an almost continuous rain, a most unusual thing in Upper Burma in the month of November, but an earnest of a fine harvest in the month of February. The Burmese are a very superstitious race, and they will consider this rainfall, which has averted what seemed the certainty of a famine in the country, as a proof that the British arms are supported by the powers of nature. Such an indication was, however, hardly wanted. We may be sure that they will accept our rule willingly, and that under its influence they will grow prosperous and forget the pride they enjoyed in having a ruler of their own race, however bad he might be.

At any rate the Upper Burmans will soon acquire the geniality which is a type of the race, and makes our older British Burmans so popular. They are favourites equally with the freshest griffin ten days landed and with the oldest resident, whose liver has made him testy for many a year. Their very faults lean to virtue's side. They are most marvellously and inconceiveably lazy. Energetic people declare that a Burman is good at nothing but steering a boat, or driving a bullock cart. But too great laziness is certainly no more objectionable than too systematic plodding. The Chinaman who grubs money night and day is not a charming spectacle. In Burma no one can starve, and there is not a beggar to be seen, except the poor lepers on the pagoda steps, and the special class who are bound to beggary by birth and religion, and who are often extremely wealthy. The ordinary Burman takes a job at carpentry work, or in the harvest field, to get a little money, and then he does nothing till he has got rid of it all. When he does make a large sum of money, he spends by far the greater part of it on some pious work, and rejoices in the thought that this will meet with its reward in his next existence. If he never gathers together enough to build any great public work, at any rate he subscribes what he can, and is generous in almsgiving to the monks. So he jogs on through a calm and contented existence, the most cheerful of mortals, troubled by no cares, and free from all the temptations of ambition. The other most obvious fault the Burman has is that he is very conceited. His religion and his physical strength, and the national literature, all tend towards bumptiousness, and whenever a Burman can assert himself he does. He has the most profound contempt for the natives of India, and will not endure being treated otherwise than as an equal, or at any rate, a non-dependent by Europeans. If you hit him, he will hit you back again. If you abuse him, he will justify himself and retaliate. This is all very well when it does not go too far, but they are frequently far too overtouchy, and resent altogether imaginary slights. This, coupled with their extremely unbusiness-like ways, makes them of very little use in offices or houses of business, and they have, therefore, very little to do in the Government departments or in mercantile houses, where the methodical Chinaman or the fawning native of India is a hundred times more useful, if in other respects not so agreeable to his chiefs. Still the Burman's sturdy independence is a great attraction in the East, where it is, in other races with whom we have come in contact, so markedly absent.

Some one with a taste for comparisons has called the Burmese "the Irish of the East." In their love of fun and rollicking they certainly resemble "the finest peasantry in the world," and they are quite as ready to break one another's heads for the mere joke of the thing; but they are much too easy-going to bother themselves with demands for Home Rule, or the organisation of land or any other leagues. A Burman is always ready to welcome a joke, and seldom is unable to cap it, while nothing is so remarkable about the natives of India as their utter incapacity to recognise wit, or to appreciate humour that is not of the broadest. The great similarities of sound in a tonic language like the Burmese give abundant opportunity for play on words, and they are therefore very free in the use of the "basis of all wit," and every dramatic piece abounds in puns and plays on words.

One of the most remarkable traits of the people is the complete equality of all classes. They are perfectly republican in the freedom with which all ranks mingle together and talk with one another without any marked distinction in regard to difference of rank or wealth. One cause of this, no doubt, is, that there are no regular working men; another, and this is the chief one, is the character of the religion. Buddhism brings all men—all Buddhists at any rate—down to the same level. The poor man may be a king of spirits in the next life, the high-placed sinner may suffer the awful pains of hell. There is no difference between man and man but that which is established by superiority in virtue. In this they remain true to the most startling teaching of the Great Master, as it is told in *The Light of Asia*. The Master had asked for milk from the shepherd's lota:—

> "Ah, my Lord,
> I cannot give thee," quoth the lad, "thou seest
> I am a Sudra and my touch defiles!"
> Then the World-honoured spake: "Pity and need
> Make all flesh kin. There is no caste in blood,
> Which runneth of one hue, nor caste in tears,
> Which trickle salt with all; neither comes man
> To birth with tilka-mark stamped on the brow,
> Nor sacred thread on neck. Who doth right deeds
> Is twice-born, and who doeth ill deeds vile.
> Give me to drink, my brother; when I come
> Unto my quest it shall be good for thee."

Burmese Buddhism is probably the purest form of that faith existing—the nearest to the teachings of Prince Siddartha, the Buddha Shin Gautama, as he is called in Burma. Every man in the country enters the monastery at some period of his life; enters it not merely as a scholar, for the monasteries are the only national schools, but actually as a member of the holy order. He shaves his head and wears the yellow robe for a longer or shorter time; for a Lent, perhaps, that is, about four months, or perhaps only for a month, or a week, or even only for a day; but he must enter it with all the formalities of renouncing the world, and he must go at least once round the village with the begging-bowl hung round his neck with the regular members of the monastery. Without this he has not gone through "Buddhist baptism;" he has not attained to "humanity," to the full privileges of a man; he could not count his present existence as other than an animal's; all the evil he did would swell the sum of his demerits, but not a single good action, no uttermost act of charity or devotion, would be recorded to his advantage in his next transmigration. Man has less innocence than the animals, and cannot, like them, progress by merely omitting to sin. On entering into a monastery, the lad—for almost all become probationers in their teens—assumes a new name, which, on the analogy of Christian, may be called his Buddhist name. This he retains as long as he remains in the holy building; when he leaves he resumes his worldly name again. This entry into monastic life is, therefore, certainly the most important event in the life of a Burman, and it influences the life of the whole people. Except in the big towns in our provinces, the great mass of the population get their education in the monastic schools, before and after their induction. Teaching is all that the brethren of the order do for the people. They have no spiritual powers whatever. They simply become members of a holy society that they may observe the precepts of the Master more perfectly, and all they do in return for the alms lavished on them by the pious laity is to instruct the children in reading, writing, and the rudiments of religion. But it is precisely this moderate amount of teaching, revealing, as it does, all the stern simplicity of the monastic life, that keeps Buddhism so active in the country, and resists the efforts of Christian missionaries in Burma. The tone of the monks is undoubtedly good. Any infractions of the law, which is extraordinarily complicated, are very severely punished; and if a pohn-gyee (or "great glory"), as the monks are termed, were to commit any flagrant sin, he would forthwith be turned out of the monastery to the mercy of the people, which would not be very conspicuously prominent. Beyond their teaching, the monks act simply as models to the people. Buddhism is a very pronounced form of atheism, notwithstanding the similarity of many of its precepts to Christian doctrine. In a religious system which acknowledges no supreme Deity, it is impossible for any one to intercede with a Creator whose existence is denied, on behalf of a man who can only attain to a higher state by his own pious life and earnest self-denial. The religious are, therefore, only higher members of a community in which every individual is striving at a greater degree of sanctity. For this reason the doors of the monastery are always open as well to those who wish to enter as to those who wish to leave it. The longest stayer has the greatest honour.

In return for their self-denial the monks are highly honoured by the people. In Upper Burma all bow down when the mendicant passes, and the women kneel on each side of the road. In our lower provinces such outward marks of respect are not usual in the larger towns, but there is no lack of veneration, and all make way for him when he walks abroad. The oldest layman assumes the title of disciple to the last inducted brother, and with clasped hands addresses him as Payah, the highest title the language affords. The monk's commonest actions, walking, eating, sleeping, are referred to in honorific language different from that which would be used by a layman, or even of the king, performing the same thing. Finally the Pohn-gyee's person is sacred and inviolable. Nothing he does can subject him to the civil law. He bears the title of Thageewin-Prince, as the heir of the scion of Kapilavastu and receiver of his inheritance.

Religion pervades Burma in a way that is seen in hardly any other country, perhaps because every one has, at some time, been a monk. No Burman will take animal life, even of the most noxious kind. Stories are told of mothers who have allowed snakes or scorpions, that have bitten their children, to escape unharmed. Our man in the moon is, by the Burmese, changed into a rabbit, because Gautama, when he was on earth in the form of that animal, made a peculiar sacrifice to a previous Buddha. All creatures on earth were bringing presents, the lion brought venison, the hawk dainty birds, the bee honey. The rabbit thought—"What can I offer?" Grass is no use, for I cannot bring enough to make a couch. Therefore I will offer my body to be eaten." For this sacrifice, the form of the rabbit was placed in the moon. The tale naturally recalls that in "The Light of Asia," where the Brahmin resigns his life that the tiger and her cubs may not die of famine. The "duty days," as the days for worship are called—the first and eighth of the crescent moon, the full moon, and the eighth of the waning—are kept a great deal better than Sundays in most Christian countries. On special festivals the pagoda platforms are thronged by crowds varying according to the sanctity of the place, and at no time almost can you visit any pagoda with a repute for sanctity without seeing some devout people reciting the lauds of the Buddha before the shrines. The number of pagodas in the country is altogether extraordinary. There is no village so poor but that it has its neatly kept shrine, with the remains of others mouldering away round about it. No hill is so steep and rocky, or so covered with jungle, as to prevent the glittering gold or snow white spire rising up to guard the place from ghouls and sprites, and remind the surrounding people of the Saviour Lord, the teacher of Nirvana and the law. The banks of the Irrawaddy are lined with them from the source to the northern hills. The number of them at Pagan, an ancient capital, renders it one of the most remarkable sacred cities in the world. A Burmese proverb says there are 9,999. Whether that is true or not, they cover an area of nearly sixteen square miles, and are of every order of architecture and in every stage of decay, some with cloisters and chapels, and ante-chapels, as fine as many a cathedral and built in the form of the cross, others with the light grace of the minaret, others again rounded like the Hindoo dome, some that suggest the bamboo-modelled pagoda of China, others a mere Border "peel," finally the ordinary bell-shaped solid mass, characteristic of Burma itself; some gilt and white plastered as fresh as if new built, others mere heaps of crumbling bricks. The most picturesque group is, however, at a point on the river a few miles below Mandalay. The Irrawaddy here makes a grand sweep to the westward. On the left, as one ascends, are the bare, rocky Sa-gaing hills; on the right the well-foliaged banks at Ava and Amarapura, rising here and there into knolls and little hills with rocky faces to the river front. All three towns, Ava, Amarapura, and Sa-gaing, if now they can be called towns, are ancient capitals. Hence the abundance of religious buildings. On the Sa-gaing hills, stairways, some of them over a mile long, wind up the steep slopes to the pagodas on the top, steps in some places hewn out of the rocky hillsides, in others laid with square blocks of alabaster. The shrines are not merely on the hill tops. Down on the cramped space at the base many more, conspicuous among them the huge solid cupola of the "Pumpkin Pagoda." On every practicable spot of the ascent there are more, some mere bell-shaped masses of bricks, surmounted by the invariable "umbrella" glittering with gold-leaf and musical with scores of little bells, hung from the concentric circles, rising one above the other in lessening size. Opposite more pagodas rise up in massive dignity on the river bank, or show their slender spires further back against the green boughs of gigantic trees. The sight, with the background of the huge dark Shan hills to the eastward is striking and beautiful in the extreme.

There is good reason for this multiplication of fanes. No work of merit is so richly paid as the building of a pagoda. The pagoda founder is regarded as a saint on earth, and when he dies he obtains the last release, for him there are no more deaths. The man who sets up a row of water-pots on a dusty road does well; he who raises a sacred post, who builds a rest-house, presents an image or a bell, or founds a monastery, gains much merit and ensures a happy transincorporation when he passes away; but the Payah-tagah is finally freed from the three calamities, his merits outweigh the demerits and he attains the holy rest. It may be remarked that it is of no avail to repair a previous dedication, unless it be one of the great world-shrines at Rangoon, Pegu, Prome, or Mandalay. In the case of ordinary pagodas the merit of the repair goes not to the restorer but to the founder. Pagodas are built over relics of the Buddha, or models of them, over the sacred eight utensils of a mendicant or imitations of these, and over copies of the sacred books.

I have spoken at this length about the religion of the Burmese, because their religion enters into everything they do, and because their religious buildings are the most conspicuous things in the country, the only conspicuous buildings indeed, for the Burman's house is a very insignificant erection, usually of bamboo and mats, sometimes of timber, but never of anything more substantial. But notwithstanding their devotion to Buddhism, they have a great many superstitions derived from the Shamanism which was undoubtedly the faith of their forefathers before Buddhaghosha came among them as an apostle. These heresies are also kept alive by their contact with the spirit-worshipping hill tribes who surround them.

The most singular of these beliefs is that which affects the naming of the Burmans. The consonants of the language are divided into groups, which are assigned to the days of the week, Sunday having all the vowels to itself. With all respectable families it is an invariable rule that the child's name must begin with one of the letters belonging to the day on which it was born. For example, Friday has *Th* and *H*, and a child of that day might be called Moung Thet, Mr. Life;

Moung Hoh, Mr. Yonder; Mah Thin, Miss or Mrs.) Learned; Mè Thaw, Mrs. Noisy; or Mee Han, Miss Haughty. Also—corresponding to the English rhyme, "Monday's child is fair of face," and so on—they have a notion that according to the day of the week (or rather the constellation representing that day) on which a man was born, so will his character be. Thus a man born on Friday will be talkative; on Saturday, quarrelsome; on Sunday, parsimonious; and so on. Not only has every day its special character and its fixed letters, but there is some particular animal assigned to symbolise it, and red or yellow wax candles are made in the forms of these animals to be offered at the pagoda by the pious. Each worshipper offers a creature candle representing his birthday, or that of any particular friend or relation whom he wishes well. In this way Friday is represented by a guinea-pig, Saturday by a dragon, Sunday by a *Kalohn*, the fabulous half-beast, half-bird, which guards the terrace of Mount Meru, Monday by a tiger, and so on. This superstitious idea has considerable ramifications; for example a woman born on a Friday ought not to marry a man born on a Monday. One or other, or both of them, would die if they persisted in marrying one another. Similar unhappy conjunctions are the union of couples born on Saturday and Thursday, or Sunday and Wednesday. Burmese young ladies know all these "hostile days," as they are called, well enough; they are set forth in jingling rhymes, and as they know the day a man is born on by his initial letter, they cut short the supplications of a swain who would rush on his own ruin. On the other hand there is an elaborate figure to show what unions, according to birthdays, will be lucky. Sunday and Tuesday, Thursday and Friday, and Monday and Friday, are some of these benignant combinations. In addition to this there are some months in which it is exceedingly unwise to get married. Nevertheless, though there is all this trouble in getting a wife, complications undreamed of by our novel writers, the Burmese manage to get married very early. Some of them also get married very often, but these are only rich people, and in our lower provinces public opinion is against it, though the law is not.

Other notions about luck and ill-luck in connection with days of the week are that Tuesday and Saturday are bad days to do anything. If you commence an extensive work on either of these days, you will soon die. But Thursday is a good day; so is Friday, if you are a student, you will become an authority if you commence your reading on that day. On the other hand the Burmese believe, as our sailors do, that it is a bad day to begin a voyage. Saturday is a bad day for everything, especially for fires. Washing the head is a very serious matter in Burma, where both men and women have very long locks, not uncommonly, in the women, so long as to trail on the ground. It is, therefore, as well for them to know that it is unlucky to wash the head on Monday, Friday, or Saturday. Beyond this, men born on certain days are exposed to dangers in particular months. Children born on Wednesday or Friday ought to be very careful what they do in the months of May, September, and January. The best thing is for them to do nothing, and in Burma they act on the precept with great zeal. So it is with other days during other months. On the other hand, there are days which are exceedingly lucky in particular months. Thursday and Saturday are the best days in January, and Thursday and Tuesday in February. I must, however, remind you that these days are only lucky for those who were born on them, and not for everybody.

Naturally, where there are so many snares awaiting the unwary, there are hosts of professional wizards and fortune-tellers to keep people who can afford to pay for it from getting into trouble. They act as doctors as well as wise men, and deal in cabalistic squares and symbols of the most impressive kind. When a love-sick maiden wants a love philtre to win back a truant swain, she visits the Hmawsayah, and gets, along with the draught, a long string of mixed sense and nonsense, which she has to repeat before a figure representing the base, deceiving young man. When a man wants to build a house he consults the doctor, so that he may know what kind of wood to use, what month to begin it in, and on what day in that month, and what the soil should be like. The doctors, when they have to cure sick people, hark back on the birthday again. There are two sects of doctors, the druggists and the dietists. The latter especially affect the birthday nostrum. They will not let a man born on a Sunday eat any articles of food whose name begins with a vowel; eggs and cocoanuts, for example, are strictly forbidden. Similarly, a Monday's child must refrain from seasoning his curry with ginger or garlic, and must avoid any edible whose Burmese name begins with a *k*, a *g*, or an *ng*, or any of these letters aspirated. The druggists are no les astonishing in their specifics. One of them exhibited to an astounded English doctor a green powder nostrum, with the information that it contained 160 different ingredients, and was infallible in its results. No doubt it was. The man who could not be affected by one of these ingredients could hardly have been worth curing.

But under such circumstances the Burmese hardly appear to their advantage. It is on one of the great pagoda feast days that they are seen at their best. Then it is difficult to say which sex is the more brightly dressed; the men with their brilliant turbans and gorgeous costly silk waistcloths, not unlike a kilt with a long end, either thrown over the shoulder or tucked in at the waist, or the women with their gay neckerchiefs, snowy white jackets and tamehns, or skirts, of endless pattern and striking contrast of colour, red or white flowers wreathed in their jet-black hair, and jewellery in extraordinary profusion. The sight is one which is not readily forgotten, and is impossible to describe. Wind-stirred tulip-beds, or a stirabout of rainbows, or a blind man's idea of a chromatrope, are the only suggestions which can be offered. After devotion at the pagoda, there is the meeting with friends from remote parts of the country, the picnicing in the rest-houses, and the religious and other plays at night, when the old people gossip and listen to the moral declarations from the stage, while the young people do as much flirting as can be managed under the circumstances.

The freedom which the women enjoy in Burma is not to be paralleled anywhere in the East. All the money and possessions which a girl brings with her on marriage are kept carefully separate for the benefit of her children or heirs, and she carries her property off with her if she is divorced, besides anything she may have added to it in the interim by her own trading or inheritance Thus a married Burmese woman is much more independent than any European, even in the most advanced states. The Burmese maiden disposes of her affections as she pleases, marries the lad she likes best, and separates herself from him afterwards if he offends her, by the simple process of going before the village elders and stating her case. If the complaint is just, the request is never refused. The women, though they are not nearly so well educated as their brothers, are, nevertheless, wonderful managers. A farmer's wife will carry out the sale of the whole rice-crop to the agent of an English rice firm, and generally strikes a better bargain than the farmer would himself. If the village constable is away, the wife will get the policemen together, stop a fight, arrest the offenders and send them off to the lockup all on her own responsibility. The wife sits by no matter what business is being transacted, and often puts in her opinion quite as a matter of course. In fact she is virtual master of the house, and henpecked husbands are not by any means uncommon—in fact King Theebaw was a notable instance.

Courting in Burma is carried on under somewhat singular conditions. The lovers never meet alone. Walks in lovers' lanes and rendezvous *à quatre yeux* would be looked upon as highly improper, no matter at what hour of the day. There is a fixed hour for the occupation—about nine o'clock at night, which is in fact commonly referred to in the country as "lads go courting time." Preparation is duly made by the girl. She gets herself up for conquest, and calls in some friends to support her. The lover, also with a friend or two, comes round at the courting hour and makes his presence known by whistling, an accomplishment at which many Burmans are not by any means proficient. To avoid useless labour in blowing out their cheeks in futile attempts to get to the sounding point, some of them, therefore, bring one-stringed fiddles with them, and saw backwards and forwards in a somewhat agonising way. This he has to do till the girl signals that the old people have gone to bed, for the old people are not allowed to be present in the room, though it is said that the mother has always a crack in the wall through which she can survey operations, and see that the *soupirant* is a suitable personage. When the flirt of a handkerchief has announced that the coast is clear, the lover ascends with his supporters, and they sit down in front of the girls and smoke and philander as much as they can under such conditions. Kissing and caressing are not permitted. Such proceedings a Burmese girl would consider highly indecorous, no matter how many people were looking on. If the parents do not object, a very few meetings of this kind are enough, and the pair are married off with the most ardent-lover-like rapidity. The marriage is a mere civil rite, and depends more upon the publicity of the thing than anything else, and separation is just as simple. It is not an easy matter to blame the Burmese for this. The system puts a speedy end to unhappy and ill-assorted unions; and, as a matter of fact, divorces are not common, and the parties are always made the butt of the village wits, and not uncommonly marry one another again when they have thought it over.

Of the sports of the people I have not the time to say anything. It is enough to say that the Burman goes wild with excitement over boat-races, and foot-races, and pony-races, that he wrestles and boxes with equal vigour, and that he rejoices in the introduction of English football, because, as he says, it is "just like fighting." Unfortunately, he gambles almost as freely as the Chinaman on anything on which money can be staked. Nevertheless, he is an extremely good fellow, manly, good-humoured, and kindly.

It is commonly asserted that the Burmese all smoke, and that Burmese babies cry for a cigar instead of crying for the moon. This is not so. Burmese children never smoke before they can walk, but as soon as they can do that they start with cigars that might do as walking sticks for them. It is quite common to see a lot of little boys and girls in the street making mud-pies and puffing clouds with equal enthusiasm. Burmese cigars are very big, nearly an inch in thickness, and they round a young lady's mouth a little too much, perhaps. But they smoke them all the same, and the usual present a Burmese belle makes to the favoured swain is a bundle of cigars rolled by her own fair hands.

There can be no doubt that the people are satisfied with our rule. They grumble at the taxes of course, but everybody does that everywhere. Nevertheless, it seems undeniable that our system might be considerably improved. In Lower Burma we have based our land revenue and capitation tax on the old national system as we found it laid down in the codes when we annexed the country. But officers trained in India have modified it according to their Indian experiences, and the result is, perhaps, not very happy. Thus our capitation tax is levied at rates which vary in different districts from one to five rupees, but every householder, rich or poor, has to pay the same. Our land revenue is collected on all cultivated lands at rates varying, according to circumstances, from less than a rupee to five rupees an acre. In Upper Burma there has been theoretically no land-tax at all. The land-tax is, no doubt, an admirable form of raising revenue, but the system does not seem to suit the Burmese, and one result has been a tendency for the proprietary right in land to pass into the hands of money-lenders and capitalists, a fact which would be very adverse to the well-being and happiness of the people generally. The holdings are usually very small. Along the old frontier they averaged only about five acres; in the Rangoon district from sixteen to twenty acres. Larger tenancies are, however, entirely against the genius of an easy-going people like the Burmese, and it would be a misfortune if our system improved away the humdrum and lazy, but good-natured and well-affected, old farmer. In favour of the capitation tax hardly anything is to be said. The people pay it dutifully enough, but it is unjust, because it presses equally upon rich and poor, on the young man just starting in trade or in a farm, and on the wealthy old trader or money-lender who lives close by. Money is so easily got that the grievance does not become serious; but if it could be remitted or converted into some tax on consumption, the boon would be very considerable to the poorer classes. Under our present inelastic system, not only is no exemption granted to the very poor on account of their poverty, and no additional demand made on the rich on account of their wealth, but the traders get off without paying their proper share. The traders are much more wealthy than the agriculturists, yet they pay little but the capitation tax. If an income-tax, the principle of which exists in the national Burmese system, though it never appeared in reality except as oppression, were established, the general result would be much fairer. Particular care will have to be taken in this respect in our new province, for not only are the people there most abjectly poverty-stricken, but they have no notion of what taxes are collected for unless it be for the special benefit of the rulers. They will have to be educated. Burma is progressing fast enough as it is. The abundance of rich land, the facility with which rights over it can be acquired, the great demand for rice and the ever-increasing counter-demand for European manufactured goods, the cessation of all irregular and unexpected collections, the absolute security enjoyed by all under the British administration—all these benefits have resulted in trebling the population of the lower provinces since we took charge of them; in the more than trebling of the trade, the value of the sea-borne merchandise alone having doubled and reached thirteen millions sterling during the last ten years; and in the wonderful increase of revenue, which makes Burma the most valuable of all the provinces under the Indian Government.

DISCUSSION.

The CHAIRMAN said it was desirable in the discussion to avoid political questions.

Mr. CHANTOON said, being a native of Burma, he should like to make a few remarks. Of course, it was now not a question of annexation but rather of government. Annexation of the Burmese Empire had been brought about through the foolishness of three kings in successive generations, but he thought the form of government to be desired would be a more direct government from England than through India. The inhabitants of Burma, buoyed up with the hope of being released from tyranny and usurpation—because Theebaw was not the rightful heir to the Burmese throne, having elder brothers, and the massacres which were narrated in the daily papers were the result of his efforts to secure the throne for himself, —willingly surrendered their arms to the English, and so there was very little fighting at first. Now the Dacoits—who were found on every occasion when there was disturbance in the realm—had more or less become either followers or leaders of insurrection, and they had been aided by the former Princes, who would continually rise out of nothing, and would melt away into nothing. He wished to urge that all British Burma, being larger than any Presidency of India, should be committed to the charge of the oldest and most experienced officers of the Indian Government, who would not in any way be tainted with power, because the Burmese had been accustomed more or less to tyranny and absolute government; secondly, that there might be access to the Sovereign power in England directly from Burma, and that this might be effected by direct government from England without the interference of India at all. The Burmese had not the same customs, manners, and institutions as India, and did not wish to be allied with it. Formerly British Burma was very small comparatively, and being close to India, might be governed by the Governor-General, but now, as it was larger than any Presidency, it might be made into more of a colony than a dependency. He believed if direct government from England were announced, it would satisfy the people of Upper Burma, and lead them in great measure to put down their arms; as they had an aversion for the Indians, as had been said. With regard to the manners and customs, of course Mr. Scott was a great authority, having lived amongst them for several years, but he being an Englishman would naturally take a different point of view from a native. When King Theebaw came to the throne about 1878, it was said in the *Standard* that he sent ambassadors through Burma, and that they were stopped, and when they returned to Mandalay they were beheaded, but this was entirely a fable. The ambassador who led the suite died of some fever, which was very usual there, and not through the king's orders. The king would not interfere with his subjects in that way, and the massacres they heard f were not the result of a wanton love of slaughter, but only to secure his throne. At present they heard of insurrections in the country, and it was doubtful when they would be put a stop to. As had been said, they knew nothing of the population, no census having ever been taken; and the Burmese knowing the country better than the English who had never been there, would rise from here and there and attack the English, and it would take a long time before order was thoroughly established; when they were once quieted, however, the Burmese would think there had been no change of government. Through their love of sport, the civil population were quite capable of acting as soldiers. He thought himself that annexation had been declared too soon, that there had been no cause to justify it. It was simply a breach of international law to annex Upper Burma, and he believed in the new Parliament something would be said on that point, that the Government had no right to embark on a war of that kind without the consent of the people, or the Parliament which represented the people. With regard to the treatment which Englishmen were subjected to, he could only say that if people went into a foreign country they must submit to the laws of the country. If a foreigner came to England, he did not expect to be ruled by the laws of his own country, so in the case of the captain who was put into the stocks, if a Burman had done the same thing he would be treated in the same manner; it was not because he was an Englishman, but because he had violated the law of the land. He would conclude with the interesting subject of the women of Burma. Mr. Scott had described the women very favourably, saying that they had a better position than in any country in the East, or even in the more advanced nations of Europe, and of course, he, being a Burman, could not but agree with that. The women did play an important part, for even King Theebaw himself was governed by his wife.

Mr. MARTIN WOOD said there was a remark at the close of the paper with regard to surplus revenue in reference to which he should like to elicit the Chairman's opinion; and he wished Mr. Scott had included in his paper a few statistics showing the revenue and expenditure of Burma as compared with India as a whole. It was commonly said that Burma yielded a considerable surplus to the general Indian revenue, and it would be as well if the exact amount could be stated.

Mr. SCOTT said he believed a million sterling was the surplus.

Mr. MARTIN WOOD said he knew that was the popular belief, but he could not think it was anything like that if the accounts were properly taken, and Burma were charged with a fair share of the military expenditure of India. The present annexation had been carried through so easily in the first instance, and the prospect of further surplus revenue was so pleasantly referred to, that everyone was satisfied at present; but he thought the Chairman would tell them that there would be difficulties to overcome, and costs to be incurred, so that public anticipations should be a little moderated. There was one question, not quite a political one—that of the administration. The last speaker had formulated the demand, which they had been familiar with from Rangoon, that Burma should be under the Imperial Government rather than that of India. There might be a good deal to be said for that; but at the same time there was probably something to be said on the other side, and he rather thought it would be worse for the Burmese to be under the Colonial Office than under the Indian Government. The interests and desires of the Anglo-Indians resident in Burma could be understood. They had, no doubt, felt or made friction between their mercantile interests and the wholesome restraints which the Indian Government had always carefully maintained; and all these things should be duly taken into account when pressure was being put on to place Burma under the direct rule of the Crown instead of under that of the Indian Government.

Mr. HYDE CLARKE said he was glad Mr. Wood had referred to the question of revenue, because one matter which affected many practical men was whether this new acquisition would meet its expenses. This, in fact, was the consideration in respect to the delay in determining the annexation. Naturally, in the first instance, it was argued that there must be a considerable outlay in meeting the charges of such a new Government under the circumstances which had been described. At the same time the prosperity of the old lower provinces must be taken into account, which had been the means of yielding so much to the Indian revenue. It would naturally be expected that there would be an increase of that revenue from the influence of Upper Burma upon it, and that a growth of revenue and surplus was to be looked for which should be set off against any possible deficit in Upper Burma, until such time as that district met its expenses and proceeded in time to yield its own surplus. Looking at these considerations, it was possible to regard the annexation without financial misgivings, and with favourable expectations.

Prof. RHYS DAVIDS thought the discussion had rather wandered into those doubtful regions against which the Chairman had warned them, but if so, it was in some degree due to the character of the paper, because Mr. Scott had overwhelmed them with such a mass of information, that the unfortunate people who had not been to Burma had naturally felt that there was nothing else to add except their own opinions on the political question. If he might be allowed to transgress for a few moments in that way, he heartily endorsed the view put forward by the first speaker, and hoped that British Burma would be made into a Crown colony, not governed from India, but direct from England. As one who had studied a little the habits and religion of the Burmese in their ancient books, he was somewhat shocked by one or two statements put forward by Mr. Scott. For instance, he said that to put up water pots on the road side, or to build public rest houses for the accommodation of the travellers, were works of great merit according to the Buddhist belief, and it was also a merit to build a pagoda; but if anyone repaired that pagoda, the merits of the work would be attributed to the original builder. Now that seemed to him to be a very unjust decision, and he should be inclined to doubt whether the Burmese from whom Mr. Scott derived that information were quite correct in their casuistry. He should think, according to the good old Buddhist law, that the merit would be awarded to the man who repaired it. Then it was also said that if a man built a pagoda he would not only get a better chance of transmigration in the next life, but would immediately obtain the holy rest, or Nirvana. He was astonished to find that the modern Burmese had gone so far from their old books, according to which man could only get to the holy rest by a change in his inner character, which no doubt might be symbolised by the outward building of a pagoda, but was not necessarily accompanied by it. These little objections, however, only referred to small details; and he could only say that he had listened with immense pleasure to so good a description of the habits and customs of the Burmese. He only wished there were more men who would deliver lectures of this kind, and give real facts with regard to the practical influence on daily life of these interesting and ancient religions.

The CHAIRMAN said before touching on the paper itself, he would deal with the statement at the end of it, which described Burma as the most valuable of all the provinces under the Indian Government, and in respect to which he had been specially asked by a previous speaker to express his opinion. He quite agreed with Mr. Martin Wood that there was a little exaggeration, though no doubt British Burma at the present time had a considerable surplus revenue. Still if a complete account were made out from the first occupation down to the present time, including the cost of the military operations, and the maintenance of the army there, with a share of the expense of the central government, and an account taken of all the years during which Burma paid nothing, there would probably be but a small balance on the total account. Of course it must be said of British Burma, as will no doubt have hereafter to be said of Upper Burma, that for the first years it paid very little, while the expenditure was very great. That was the case in British Burma, and certainly would be the case in Upper Burma. He quite agreed with one of the previous speakers that there was very likely an exaggerated idea of the immediate financial results of the annexation, but he felt quite certain that in considering the question the Government had been in no way influenced by a mere consideration of the profit to be derived from it. The subjection of Burma was undertaken on purely different principles, and really because, as those responsible for it maintained, the thing was absolutely unavoidable. Those who had watched the course of events carefully had satisfied themselves that at present no other course was open to them. There were a number of complicated questions which he could not go into, of a pressing nature, connected with our position in Indo-China which, to his mind, made it clear that no other course was open than to annex it to the Crown. The proclamation was very carefully worded, and left it open to the Government to take any course it liked in respect to the future. He hoped the form of administration would be to employ a large number of the natives of the country in the Government, and not to have too elaborate a system; in that way it might be made to pay its expenses in the course of time, but not at once. He would also warn the public against a too exaggerated notion of the trade results likely to immediately follow on the annexation of the country. As far as he knew, the trade of Burma had been carried on and had developed very largely, although under great difficulties, and he did not see any immediate prospect of its being increased to any great extent in consequence of the opening of Upper Burma. No doubt it would grow, but those who expected an immediate increase forgot how very far the dense populations of China were from Burma. It was a long, difficult, and almost impracticable road, from Bhamo to the populous parts of China. It was all very well to say China was only 33 miles from the Burmese frontier, and then to talk about opening up trade with 300,000,000 of Chinese, but those Chinese were naturally not in the barren mountains; they were on the rivers, and in the valleys, which were already provided with trade by another route altogether, which would never be superseded by a long difficult land carriage. At the same time, no doubt, under good government, and working hand in hand with the Chinese, there would gradually spring up an increase of trade which was very considerable already. But he did not think the annexation was to be justified by the hope of profit, or by a large increase of trade; he was convinced it was to be justified on much higher and more honourable grounds. With regard to the question of direct government by the Crown, it was a subject he could not very well discuss, nor did he quite understand on what ground it had ever been maintained that benefit would arise from it. He could only say with regard to British Burma, that he did not know any part of the East, or any Crown colony, which had been so successfully administered, where so much progress had been made, or where the people altogether, as far as he could collect, both Europeans and natives, appeared so prosperous and so generally satisfied with the state of things which existed. He did not see how they would be better off as a Crown colony than they were now. The idea, of course, arose in connection with this large surplus revenue, which was so often talked of; they had just heard Burma called the milch cow of India, but that was an exaggeration. Comparing the surplus revenue of Burma with that of Bengal or other provinces of India, it was a very small matter. He had been to several Crown colonies, and he did not see anything in which Burma would benefit by being made a Crown colony. To come to the lecturer, Mr. Scott, he thought they were all very much indebted to him for the information he had given; Burma was a very large subject, and could not be fully dealt with within the limits of a paper, but he hoped Mr. Scott would be induced to continue those published sketches of Burmese life by means of which he first came before the public, and which had been so favourably received; these had placed the Burmese in a very pleasant light. There were three points in the paper which struck him as specially deserving consideration, the historical, the religious, and the social. It was impossible to discuss these at length, but with regard to the historical portion, he hoped Burmese history was not very accurate, and that some of the Burmese kings would bear, if their lives were fully known, a more favourable view than Mr. Scott had been able to take of them from the materials at his disposal. At the same time, of course, he was speaking of barbarous times, and no doubt in those times barbarous things were done. One of the facts he had mentioned showed very clearly how the ignorance, arrogance, and inflated pride of the Burmese had brought about the present state of things. The quotation Mr. Scott had made from the minute of Lord Dalhousie, written thirty years ago, showed that what we had to complain of now was exactly what was complained of then, and that the warnings then given by Lord Dalhousie had not had any practical effect in inducing the Burmese to change their mode of dealing with foreign powers. Again, it was very interesting, as bearing on passing events, to notice Mr. Scott's statement that Alompra four times repelled the invasion of the Chinese, who ventured to press him for tribute, rather than submit to these claims. He must say he did not find any case in support of the view put forward on behalf of the Chinese that they had any right to the suzerainity of Burma. The only agreement that he could find on the subject was that of 1769, made between the Burmese and the Chinese Generals at a time when Burma had beaten the Chinese. An agreement was then come to that for the future, with view to maintain peace—to maintain the golden road as it was called—there should be every ten years a mission from one Government to the other bearing presents and friendly letters. There was not a word which would bear the interpretation of tribute, or inferiority, and the king and the people of Burma had always stoutly maintained that they were not in any way tributary to the Chinese. It was now put forward by English writers, on behalf of the Chinese, that the case stood on letters written by the King of Burma, published in the *Pekin Gazette*, in which he used expressions in Chinese admitting himself to be a tributary of China. Now, the Burmese did not know Chinese, and, therefore, could not have written in the Chinese character, so that the particular letters must have been Chinese translations. They knew that the Chinese were in the habit of treating the most ordinary acts of courtesy as acts of homage from an inferior, and a Burmese gentleman, a few days ago, said what was no doubt correct — that it was quite true that the Chinese represented the presents to them as tribute, but that the Burmese records would show that they had also represented the Chinese presents in return as a tribute. That was the way of Orientals, and there was nothing to be gained by referring to these letters. The whole question had in fact acquired an undue importance, for no one could doubt that it was to the interests of China and England that we should become friendly neighbours, and work together, and that was to be obtained by measures entirely unconnected with any reference to unreliable history. There should be no difficulty in coming to some agreement to work together in civilising that part of the country. As regards the religion of Burma, with all due deference to the criticism of Mr. Rhys Davids, which was probably perfectly correct as an abstract interpretation of Buddhist religious work, his own impression from, he admitted, a not very long residence, was that the repairer of a pagoda did not gain any merit from it. No doubt there might be something wrong with the Burmese interpretation of their books, but there was, he thought, no doubt of the fact, and it was rather difficult, in consequence of this, to get pagodas repaired; for though they were always being built, they were built badly, and were constantly tumbling down, and the place was covered with ruins. He thought Mr. Scott had correctly described the Buddhist religion as far as it was to be learnt by a foreigner in the country. It had, as Mr. Scott had said, an extraordinary influence over the life of the Burmese. They were most earnest and devoted, and spent a great deal of money and time in their ceremonies. He recollected Bishop Milman, when he visited Burma, was immensely struck with the earnestness on pagoda days with which the whole community were doing what he described as "praying to nobody to become nothing," which was a very terse and accurate description of the Buddhist religion, as explained to the casual traveller. As regards their social life, although the Burmese might be a little idle and careless, they were very genial and taking in their ways; no one who had not seen them in their villages and sports could understand how happy they are. Going there, as he himself did, from the stiff, ceremonial, and solemn life of India, he was delighted with the easy, social, fun-loving life of the Burman. The effect of this was apparent in the much better feeling and the great amount of harmony which existed between the English and Burmese of India—they were much better friends, and had more in common. As to the future of Burma, as he had already said, too much might be expected of it; but he believed in the course of time, as the Shans moved down to Upper Burma, they would take up an enormous amount of waste land, which would be cultivated, but which now had hardly any population worth speaking of, though, at the same time, a great deal of the present population would, at first, move down into British Burma, making Upper Burma itself still more of a desert; but there was a great deal of magnificent land there, and in the States around there were people who were anxious to get good land for cultivation. On such an occasion, especially when there were so many Anglo-Burmese present, it would not be out of place to express their sense of the great loss the country had sustained, and Burma in particular, by the death of Sir Arthur Phayre. He was the first and best ruler British Burma ever had. He took charge of the country at a time when it was disorganised after the annexation, and had to work with a number of officers who had not, most of them, had much training in civil life He devised the whole system of administration in Burma, and thirty odd years' experience had suggested very little in which required change. It was an enormous work, and one for which he deserved the highest credit. He was admirably served by the men he got together. He trained them, and influenced them, so that they became a hard-working zealous set of officers, who had a sympathy for the people beyond anything which he had been in the habit of seeing in India. After many years service he left Burma, beloved by all classes of the people, by Europeans and natives, rich and poor, and his name was venerated there as much now as when he left the country. They must all join in wishing that they had the benefit of his advice and counsel in the present emergency.

Mr. CHANTOON remarked that when a Buddhist built a resting-place for travellers on the way, he was supposed to do a good work. That was, more or less, charity. With regard to building a pagoda, if it was his intention to honour Buddha that was a merit; but if he built a pagoda for his own glory to be known in after years, then it was no merit whatever, it was only selfishness. As regards the Buddhist religion, he would only say it was admirably represented in England by Mr. Rhys Davids. who had collected all the oldest Pali MSS. to be found in Cambodia, Burma, and Ceylon, and he was sure that Professor Rhys Davids would be glad to give any information with regard to Buddhism to any one who desired.

The CHAIRMAN then proposed a vote of thanks to Mr. Scott, which was carried unanimously.

FOREIGN & COLONIAL SECTION.

Tuesday, January 26th, 1886; Hyde Clarke in the chair.

The paper read was—

THE IMPORTANCE OF A NATIONAL SCHEME OF EMIGRATION FOR THE BEST INTERESTS OF BRITISH COMMERCE.

By Arnold White.

There is no subject relating to the well-being of the community in regard to which it is easier to generalise than the question of emigration. At first sight it seems as though emigration, and enough of it, were a panacea for the greater portion of the national evil caused by the pressure of our population. When, however, the subject is analysed in detail, it is found to be wedged round with a variety of political and economical difficulties, which must be grappled with by the community rather than by the Legislature.

There is hardly a limit to the number of avenues from which the subject may be approached. Having regard to the constitution and aims of the Society of Arts, it may be well to state that the line of thought followed in this paper will proceed on a consideration of the manner in which the energies devoted to emigration may be organised for the purpose of increasing and developing the markets and the manufactures of Greater Britain, without, on the one hand, making undue claims on the resources of the State; or, on the other, leaving the question as it now is, in the hands of multitudinous units, working without association or hope of success on more than a limited scale.

It is an axiom among those who are accustomed to apply themselves to matters relating to the well-being of their fellow countrymen, that the truest philanthropy is that in which the capital expended is returned. The enterprises of the late Mr. George Peabody and of Sir Sydney Waterlow are but examples of the truth of this general observation; and, unless it could be shown that money expended, either by individuals or by the nation, in facilitating discriminate emigration is either directly or indirectly re-productive, I should not have ventured to place before this audience the results of such travel and investigation as I have been able to give to the subject.

The attitude adopted towards the subject of emigration varies according to the situation and interests of the observers. In England the question has been regarded almost exclusively from the philanthropic point of view. The spectacle of congested cities, of the thousands of unemployed, and the always shameful, because unnecessary, scenes of hundreds of able-bodied men clamouring at the dock gates for work which does not exist, has directed public attention to the feasibility of removing these unfortunates to another land, as an effective method of extirpating evils which are continually under process of generation.

One result of these philanthropic intentions has been to create in late years, in the Anglo-Saxon colonies, and in the United States—which is the saucer into which the European cup has overflown since 1820—a feeling of repugnance and dread of large schemes of immigration, measurable only in intensity with the sentiment excited in Australia, or in South Africa in past times, when the mother country reversed the policy of the pelican, by feeding her colonies not with the best of her blood but with the rejected elements of her people. That this sense of wrong at the idea of Britain shedding her paupers on other lands is in existence, and is growing, there can be no question. We are met, therefore, with the initial fact that, whatever may be the destination of the pauper population of our great cities, our colonies not only will not encourage tts transfer to their own shores, but will resist by every means in their power any well-meaning but misguided attempts in that direction.

The recent action of the American Government in regard to the introduction of pauper immigrants is well-known. At Castle Garden, the landing place of the immigrants to New York, an investigation is made by officers of the Customs Department as to the ability of the immigrants to pay their passages to the interior of the country, and to support themselves for a reasonable period of time. The result of this examination has been still further to diminish British emigration for the year 1885, the falling off in that year being 38,915, as compared with 1884. It is impossible not to sympathise with those beyond sea, who decline to allow the Anglo-Saxon colonies to be treated as receptacles for the failures and for the unfit of British industrial life. That this feeling is deeply rooted needs no demonstration. Of its justice no facts can be more telling than the analysis of a given number, say, of the London unemployed who are candidates for emigration. During the winter of 1884-5, I happened to be brought closely in contact with about 6,000 of unemployed men in the East-end, and I have no hesitation in expressing my conviction that not more than 4½ per cent. of their number were eligible for a new life in the colonies. A large proportion of these 6,000 were men who had, during a comparatively recent period of time, come to London in search of work; and it is remarkable that the small proportion of those who were adjudged by competent authorities as fit for emigration had, for the most part, but lately left the country districts.

These two facts, therefore, of colonial repugnance to receive the surplus population of British cities, and the unfitness of the majority of those whose presence forms a burden and danger to our social life, indicate that if the question of emigration is to be regarded as a remedial agent, and from a national point of view, the remedy must be applied before the individuals to be emigrated have sunk into the semi-nomadic conditions of casual labour in the great cities; before habits of continuous application have been lost, and before *physique* and *morale* alike are injured beyond hope of repair.

It cannot be denied that emigration has failed to touch, in recent years, the evils caused by the prevailing lack of employment, created by dwindling value and fluctuating volume of trade—and more especially by the enormous annual increase in the population of Great Britain. Such emigration as has taken place has been partly indiscriminate. During the year 1884, when 242,000 people of British origin left these islands, there was an influx during the same year, from all sources, of not less than 91,356. Of this number a large proportion were returned emigrants who had failed to make good their grip on the place selected for their attempt to obtain a livelihood.

Absence of authentic information as to the capabilities of the districts selected for settlement in the colonies and elsewhere is the first and principal cause of these unsuccessful ventures. The statements of agents and others, who are chiefly concerned in procuring the transport of a certain tonnage of emigrants over lines of railway with land to sell, have also led to the destruction of many hopes, and the permanent ruin of many lives.

The mere possession of 160 acres of land in the colonies, without the essential knowledge, strength, or capital, is no greater boon than the acquisition of the now historical three acres and a cow is in England itself, when the possessor has neither time, ability, nor capital, to develop the potential advantages of the land

The glut of artisans in England represents a state of things prevailing nearly all over the world, and the transfer of carpenters' and builders' labourers to places where the demand for those forms of industry is below the supply available on the spot, is simply a re-arrangement of suffering, and is attended with no corresponding advantage.

A second cause of the comparative failure of recent emigration to cope with the volume of English distress, is the absence of adequate capital. There are in London, at this moment, twenty-five emigration societies bravely struggling with the task of meeting the necessity of the case, some of which have done and are doing good and noble work, however limited in extent that work may be.

It is not surprising that capitalists hold aloof from the expenditure of large sums of money where the competition for their support is so keen, the results of the work accomplished so comparatively insignificant, and where special and expert knowledge of the subject by the administration is by no means a matter of course.

From investigations made in the course of last year, it appears that the twenty-five societies referred to succeeded in sending away not more than 3,500 individuals at a cost of £13,000. When it is remembered that not less than £4,000,000 are annually expended in public charities in the metropolis alone—which sum would provide £20 each for every one of the 200,000 human beings forming the submerged stratum of London life—the diversion of a moderate proportion of this enormous sum from the temporary relief of the necessitous to the permanent assistance of the able and the deserving, by means of emigration, would be, in all senses, a more productive use of the money.

Considerable efforts were made, in 1885, under good auspices, to induce the representatives of the twenty-five societies to form a Bund or Central Council, in which information might be focussed, and to which the gifts or loans for emigration purposes of the charitably disposed might be entrusted. These efforts were not successful.

Hitherto information in regard to the absorbtive capacities of the different colonies has been acquired by the disunited energies of societies or individuals. As there are ten

Agents-Generals in London more or less interested in emigration, superfluous work is involved both to them and to their correspondents and visitors, by the absence of a centre where exact information can be concentrated and dealt out.

An inquiry, however, at the Agents-Generals' offices does not appear to exhaust the well of truth as to the capacity of the colonies to receive suitable members of the British community. Democracy now reigns supreme in the Anglo-Saxon colonies. It is not surprising, therefore, that the protective policy, which is all but universal, extends not only to the exclusion of Chinese labour, but to all measures likely to lead to the reduction of wages.

The ambassadors of the colonies in question are debarred, therefore, from taking part in any movement which shall prejudice the interests of the wage-earning classes, who now form the bulk of colonial constituencies. That this is so, is, however, no reason why a serious and continuous effort should not be made to ascertain from month to month the actual condition of agricultural and other industry in and near every large town in every colony over which floats the British flag. I may, perhaps, adduce a practical instance of the importance and interest of local inquiry. The courteous and able Representative of the Cape Colony is no longer in a position to promote emigration to South Africa, as the Cape Parliament have, during its last session, rescinded the emigration vote. Detailed inquiry in the Cape Colony, however, reveals the fact that, although some of the finest wheat in the world is grown in South Africa, the colony is importing food-stuffs for internal consumption to the amount of £1,020,000 a year, and that, consequently, the introduction of agricultural labour, at least sufficient to produce food-stuffs to that extent, would be of benefit the Cape Colony, whatever the result might be to the mother country or to the emigrants themselves.

Take, again, the instance of New South Wales. The following is an extract of a letter which appeared in the *Pall Mall Gazette* of 21st June, 1884:—

> "NEW SOUTH WALES EMIGRATION.—The demand for agricultural labour of all sorts is still largely in excess of supply. The amount of genuine distress in the country may be estimated by the fact that the 'starving unemployed' have refused to accept 5s. a day on temporary Government relief works. The country is simply crying out for men, and it is pitiable to see the short-sighted efforts of those who are honestly attempting to dissuade English workmen from throwing in their lot there."

This is how Mr. Froude, in his new book "Oceana," describes Auckland, New Zealand:—

> "Eight shillings a day are the usual wages, and no able-bodied man who wants employment is ever at a loss to find it at that rate of pay. Beef is thought dear at sixpence a pound, bread is not dearer than in England, while fruit and vegetables are as much cheaper as they are superior in quality. The 'four eights' is an accomplished fact—eight hours to work, eight to play, eight to sleep, and eight shillings a day."

It is not surprising to read a little further on that the workmen "discourage immigration" as tending to lower their wages. This seems to be the result of extensive public works, affording unlimited employment, paid for by enormous loans raised at cheap rates in England; and the workmen, being in the majority, can have their own way about the immigration.

It may, then, be fairly assumed that a case is made out for independent inquiry on the spot as to the condition of the local labour markets in the colonies. There is no doubt a continuous stream of valuable information pouring into the letter-boxes of the various emigration societies, and of individuals interested in the work of emigration. But the first step in a national scheme of emigration would be to combine these rivulets of knowledge, and to filter and compare them in order that they may be made of the greatest use to the community; and, furthermore, they require to be supplemented by the patriotic support of residents on the spot. If approached with tact and address, an individual or committee in every town of our colonial possessions will probably be found willing to support, by trustworthy and impartial monthly reports, the emigration bureau of centralised information, which it is to be hoped will be formed by the Government without loss of time.

Before such a bureau is in a position to satisfy the demand for accurate knowledge, it would be necessary for one or two competent individuals to visit Australia and the Cape, properly accredited by the Government, for the purpose of enlisting the aid of volunteer helpers in the colonies, not only for the supply of trustworthy information, but for the honourable and patriotic purpose of advising and assisting those who leave England for the first time.

Much has been said and written of late about the federation of Britain with her colonies. There is no way in which the true federation of the Empire can be more practically aided than by a union with our kin beyond sea for the purpose of developing their land and assisting ours. Work such as this lies beyond the province of a Government department. That the task is one capable of achievement, the example of the Cape Colony and of Canada—to which I shall allude further on—affords grounds for hope.

The Right Honourable Sir John Macdonald, the Prime Minister of Canada, has lately given me permission to state, that in the event of such a bureau being formed, the Government of the Dominion would gladly afford all the aid in its power through the Ministry of Agriculture—which is the department in charge of Canadian immigration.

The next point indispensable for the success of a national scheme is the possession of funds. Bewildered by the multiplicity of demands for support, the English public has held aloof from the emigration movement. The subscription of £13,000 in one year from the whole of the metropolis does not suggest the idea of conviction being rooted in the public mind that the advantages, commercial or otherwise, of promoting wise emigration on a large scale, are such as to warrant serious efforts for the purpose. In the year 1884-5, £457,716 were expended in London on 92 Institutions for General Relief, Food Institutions, Loan Charities, and Homes. Investigation into the outcome of this expenditure, either to the individuals relieved, or to the nation at large, is disappointing to those who look for solid and permanent results.

Having regard, then, to the enormous sums laid out for transient advantages to suffering individuals, it does not seem Quixotic to expect that an appeal to the nation for means to convert those who now are, or will be, a burden to their fellow countrymen, into self-supporting communities across the sea—consumers of large quantities of the products manufactured by those left behind—would fall on deaf ears.

The facility with which the cry for Imperial funds is raised is fascinating to those who do not reflect that any such addition to the burdens of the State paves the way to the assumption of tasks, not only more amenable to private enterprise, but which are in fact and essence foreign to the theory of constitutional government itself.

If, however, no case as yet has been made out for subventions from the State for colonisation, undertaken with the philanthropic object of relieving pressure at home, it is conceivable that cases have arisen, and even exist, where State colonisation may be a cheap and effective alternative to a military solution of burning questions. The old system of military settlers is now discontinued, but who can doubt that but for the settlements in South Africa of 1820-1857, ill-managed as they were—so far as the management attempted in the United Kingdom is concerned—the incessant and costly burdens laid on the mother country during the last twenty years would have been even heavier still. The British taxpayer has spent about £18,000,000 on South African wars since the year 1870, an expenditure caused by the neglect of Bacon's apothegm:—

> "It is the sinfullest thing in the world to forsake or destitute a plantation once in forwardness; for, besides the dishonour, it is the guiltiness of blood of many commiserable persons."

The settlement of the Eastern Province in 1820, at the charges of the British exchequer, has again and again saved the vulnerable side of the Cape Colony from being "eaten up" by "man-slaying machines" from the east and north. This being so, the conclusion is irresistible, that the wise expenditure by England during the last thirty years of a million of money for colonising purposes, would not only have saved the outlay of the greater part of the vast sum wasted in wars, which have settled nothing, and pleased no one but the contractors, but would have created a large and permanent demand for British manufactures.

The recent expedition to Bechuanaland, involving an expenditure of over a million sterling, has left a country the size of Spain to fortuitous development, and to the chances of Boer energies and leisure. Beyond the the resources of private enterprise, the colonisation of Bechuanaland by Great Britain, at a cost of £125,000, not for the purpose of relieving home distress, nor even with the object of creating a new market for British trade, but to stock with settlers of British and loyal Dutch blood a land coveted by those who regard not their neighbours' landmark, in the opinion of those on the spot most competent to judge, would secure for the British taxpayer an assurance of peace and rest from which, under present circumstances, he is only too likely again to be disturbed. And when this disturbance does arise, it should be remembered that the sword cannot be effectively drawn 1,000 miles in the interior of Africa for half a quarter of a million of money. England has now assumed a responsibility for Bechuanaland which belongs to her whether she recognises or evades her inalienable engagements to white men and black. The alternative accordingly is offered either of making a moderate expenditure for a special purpose, which shall be as final in its way as was the cost of the colony of 1820, or of incurring liabilities which accumulate at compound interest while England sleeps.

Such an expenditure in Bechuanaland gratuitously made to the settlers chosen, would, in the course of time, pay itself. There was a married couple named Cawood who went, in 1820, to the Cape Colony, in the ship *John*, in Hazelhurst's party. There are now 500 descendants of the original Cawoods, in the Cape Colony, consuming to the amount of £1,500 to £1,600 a year of British products. The annual profit to the mother country on the consumption of the Cawoods exceeds the original cost of their settlement to the British Government. While it cannot be expected that every couple will be as profitable or as prolific as the Cawoods, their debt to the Government of the day has been more than discharged by the stability they have contributed to the colony, by the work they have created for artisans and spinners in the old country, and by the indirect advantages of every kind, arising from their having taken root in South Africa. An old writer has said "that the planting of countries is like planting of woods, for you must take account to lose almost twenty years' profit, and expect your profit in the end."

The financial aid of the State should accordingly be sought only in such exceptional cases as those now presented by the Bechuanaland or Zululand problems, and then only as affording the cheapest and most effective means of meeting inalienable responsibilities incurred toward the country requiring settlement, and not in any sense from philanthropic motives, which, however laudable in the individual, have no place in the machinery of Government.

Such problems present the dilemma of cannon or colonisation; and as the cannon solution is more costly, less permanent, and is productive of ill-feeling all round, the other horn of the dilemma appears on the whole preferable. Before quitting the subject of colonisation in connection with South Africa, a word or two on a recent scheme for renewing emigration to that quarter may not be without interest. The original idea was that Bechuanaland should form the site of the proposed colonising operations, but the distance from the sea, the fact that the land generally is adapted rather for pastoral than agricultural pursuits, and the consequent need for capital by the pastoral settlers, rendered it advisable to look elsewhere, in the first instance, for suitable land. Bechuanaland presents, however, peculiar advantages to the small capitalist of vigorous habits. Situated on a high plateau, the climate is enchanting in its freshness and beauty; and the great attractions Bechuanaland offers to the enterprising inhabitants of the Transvaal indicates unmistakeably that it is equally adapted for loyal English and Dutch settlers possessed of some means. Sir Charles Warren's expedition has opened the door to those younger sons to whom the cost of an American ranche is prohibitive, and who are unable to obtain appointments in the national services. Cold as the nights are in winter, the hardship of life is not comparable with that of Canada, or even pioneering in the tropical cultivation of tea or coffee. Bechuanaland is *par excellence* the cattle farm of the Cape Colony, and if governed with firmness, administered with continuity of purpose, and colonised by England, it must grow in importance from year to year.

It was in Kaffraria, on the eastern border of the Cape Colony, that the conditions required for a small agricultural colony were found. Soil and climate are all that can be expected. But quite as important as these essentials was the presence of gentlemen sufficiently experienced to know, and patriotic enough to impart the steps needful to success for a body of men and women desiring to take root in a new country. To Mr. H. H. Baker, Mr. J. J. Irvine, and to Mr. Geo. Whitaker, of King William's Town, who have consented to act as the trustees in South Africa of the colony in question, will be due the entire credit of the success of the scheme. The lady whose one restriction on freedom of action has been that her name shall not be allowed to transpire, has provided funds for an experiment on a fully adequate scale. The cost of this experiment, and the trouble that has been expended on thinking out all the details, and the skilled administration on the spot, are such as to leave nothing to chance. The first settlers will be young married couples, abstainers, and mostly of the agricultural class. It may not, possibly, hereafter be feasible to maintain so high a standard, but as the success of the first settlement is fraught with large possibilities, both to English and South African interests, it is considered well that the first comers should be of the nature of a *corps d'elite*. Land is being bought and irrigated, tools, stock, and implements will be found, rations will be supplied, and skilled agricultural advice afforded on the spot. It is believed that there will be no difficulty in the settlers commencing repayment of the capital sum expended on their behalf, after the first year, and the increase in the value of the property will by that time be apparent to all. The money thus returned will be used for a similar purpose.

The interest with which this experiment is being watched by the South African public is indicated by the following extract of a letter from an influential colonist resident in the Cape:—

> "If your scheme should be carried out, I should have pleasure in making an appeal for the assistance of the colonists to help the emigrants. I should be glad to form one of the number here in making a collection of stock for the new comers. The mother country has never failed to come to our assistance when required, and I do think that the least we can do is to show our appreciation of her assistance by relieving her of some of her surplus population, which would also be of great benefit to the colony, commercially as well as politically."

The Cape Government have agreed to make a great reduction in the cost of conveyance of emigrants and stores over the Cape Government railways, and a prominent firm of engineers in Port Elizabeth—Messrs. Howard, Farrar and Co.—have offered to contribute some valuable pumping machinery. Education will be provided for, and in the event of misconduct or death leading to the vacation of an allotment, compensation for unexhausted improvements will be allowed. Owing to the exceptionally favourable period at which the land and material is being bought, it is believed, by those best able to judge, that under no circumstances will there be any shrinkage of capital.

The destination of emigrants is of the highest importance to the best interests of British commerce. In 1884, 155,280 people of British origin left for the United States, and when there, consumed, *per capita*, an average of 10s. worth of British manufactures, making an annual consumption of £77,640 of British goods. The same year, 44,255 left for Australia and New Zealand, where, according to the average scale of consumption ruling in Australia, they became at once annual customers for British goods to the amount of £352,000 per annum. In other words, two Australian immigrants, as customers to Great Britain, are equal to thirty-three subjects of the United States. An emigrant to South Africa is, commercially, six times more valuable than an emigrant to the States. That trade follows the flag is often said, but the force and extent to which the British flag is pursued by British trade is not so clearly a matter of common knowledge.

If the facts stated are sufficient to induce patriotic citizens to provide adequate funds for a considerable increase to discriminate emigration, it is clear that there must be some national body or council unconnected, as a whole, with any special interest, faith, or society. A national emigration council should by no means engage in the details of sending emigrants away. To do so would involve the creation of yet another competitor in the crowd of claimants for public money. The function of the council should be to receive funds from the public and distribute them impartially to societies and individuals who have proved themselves competent and economical in the transaction of previous emigration business. Representatives of the principal societies would naturally form an important part of the council, and the first step towards federation for executive purposes would thus be taken. All the existing associations are hampered for want of funds, and any legitimate means which would increase revenue without involving interference, could not but be regarded with favour by them. The national council being, through the bureau of information, in full possession of the views and various needs of the colonies, would either stimulate or check the outflow of labour as circumstances may demand, and reduce to a minimum the scandal and suffering caused by ignorance on the part of the emigrant himself.

The other objects of the council would be as follows:—

1. To place itself in constant communication with the Colonial-office in London, with the Agents-general, and with agents appointed for the purpose in the colonies.

2. To obtain assistance from persons or societies in the colonies, who will undertake to receive and place emigrants and their families.

3. And generally to ascertain from time to time, the limits within which emigration from he United Kingdom can be conducted.

4. Having thus ascertained the possible "openings" for emigrants, to place such openings at the disposal of the various existing local agencies.

5. To receive funds, and to distribute them among local agencies.

6. The council should not attempt to make centralisation take the place of the personal care and minute attention to details which smaller local associations alone can give, but leave them to adopt their own system of work, subject to such conditions as the council may from time to time think desirable.

7. The council itself not to undertake any emigration, but if it appears that the demand for emigrants at any time seems likely to be in excess of tne supply, to organise new local committees to do the work.

It is to be hoped that this may be of assistance in the way of directing a portion of the flow of population from the country districts direct to the colonies, rather than to London or other large towns.

The existence of a national council would also be of use in the following ways:—

a. As the channel of communication with the Imperial Government.

b. As the channel of communication with the Colonial Governments, and in particular to apply to them for (1) free or assisted passages; (2) reduced rail fares; (3) immigration agency in the colonies, including further efforts to obtain openings for emigrants, and facilities on their landing.

And generally, the existence of such a council would be likely to inspire confidence in the charitable public, and thus to increase the subscriptions available for emigration.

Although England is the only country in Europe to which a national scheme of emigration is either feasible or profitable, there are some points in the practice of other emigrating nations which are not without interest in the study of this question.

GERMANY.

The influence of certain land systems in affecting emigration is shown by the province of Mecklenburg-Strelitz. The area is 1,130 English square miles, and the whole ownership of the territory is divided between the Grand Duke, feudal proprietors, and the corporations of certain towns, in the following manner—527 square miles to the Grand Duke, 353 to the nobles, and 117 to the town corporations. The population, although only 100 to the square mile, is less in Mecklenburg-Strelitz than any other State of the German Empire; the average density of the population in which is 213 to the square mile. Owing to the manner in which the land is held, the emigration from Mecklenburg is proportionately to the population three times as great as is the case in Saxony, which is the State most densely populated in the Empire.

Emigration from Germany is discouraged, and when, as is the case in some parts of Mecklenburg, districts are depopulated, the discouragement by the Government is displayed by the adoption of strong measures. The principal causes of emigration from Germany are, undoubtedly, the fear of war, the hatred of military service, the crowded condition of every department of industry, the immense competition for employment caused by the 160,000 soldiers who are yearly thrown on the world, and for whose sake, it is said on good authority, Prince Bismark acquired for the State the control of the railways, for the purpose of finding employment for a portion of the lower ranks of the German army.

The comparative success of German emigrants, as compared with those of our own country, may be attributed to the facts—firstly, that the standard of comfort in Germany is lower than that ruling in England; and, secondly, that as a family seldom or never emigrates without some small provision in the way of capital, the sufferings arising from pauper emigration are practically obviated. The German Government, like the English, take especial pains to ensure the comfort and well-being of the emigrants on board ship.

But the policy of protection, which in Germany is as comprehensive and far reaching as the military system itself, is developing year by year. One of these developments is a provision which will shortly come into force, by which the steamers conveying German emigrants must be fitted in such a way as will conflict with the regulations laid down by the English Board of Trade, and which will consequently prevent the conveyance of German and English emigrants by the same vessel.

Emigration agents, at Hamburg and Bremen, have to deposit 18,000 marks in the hands of the Government, which are liable to forfeiture, if by false and misleading representations they consign settlers to unhealthy parts of the world where success is impossible.

While the German Government discourages emigration as a whole, they are doing all they can to promote the settlement of their own recently acquired colonies.

New regulations of a restrictive nature will shortly be issued by Germany, and this being known stimulates emigration, for many towns of Germany are under martial law. Unmarried men can be ejected at twelve hours' notice, and married men at twenty-four hours' notice; a dangerous precedent for Germany, when it is remembered that there are now 23,000 immigrant Germans in London alone. The nations of Europe cannot fail to remember the action of Germany with reference to the Jews and Poles, on their eastern border, should occasion arise. It is not too much to say that half the emigrants from German ports are of the Jewish faith. They have a hereditary dislike to military service, and are more prone to apply themselves to commercial pursuits than to bear arms, though recent events in Bulgaria supply instances of an opposite nature.

The greatest depression in Germany is followed, as elsewhere, by the greatest emigration, and it is interesting to observe that the tax on corn already presses heavily on the lower classes.

The average actual number of young men drawn from the ordinary conditions of service in the army is 160,000, besides 5,000 who enter as volunteers for one year, and 5,000 for the marine.

The total population of the Empire of Germany in 1882 was 45,213,000; and 3,000,000 Germans have emigrated to the United States since 1820.

There is hardly any emigration either to British North America or to Australia; in 1881, for example, while 206,000 Germans went to the United States, only 286 went to British North America, and 745 to Australia.

The loss by emigration from Germany is estimated at not less than £30,000,000, as the emigrants, when settled in their new country, are purchasers of German manufactures and produce to a very trifling extent; it need hardly be pointed out that this is not the case when Englishmen go to English colonies.

The military system is the means by which the German Government retain a hold on individuals and prevent able-bodied from quitting the fatherland.

The Chancellor justifies his action in regard to the forthcoming restrictions and changes in the arrangements for shipping interests, by the plea that, as there must be a certain amount of emigration, it is well to keep it in German hands—that is in German ships.

Much trouble is caused to the German Home Secretary, as well as to the Imperial Commissioner for emigration matters, stationed at Hamburg (which gentleman is directly under the control of above Minister). The opinion of leading circles appears to be that it will be best to avoid an encouragement of whatever character as regards emigration, and consequently it has diminished within the last few years. The number of young Germans attempting to escape military duty is comparatively limited; statistics show the correctness of this statement.

In 1884, the emigrants carried with them about 20,000 children (under 10 years), who of course went with their parents, this proves that the majority of the 45,600 male emigrants (above 10 years) must have been married men, who had served their time in the army. The emigration of young men between the ages from 17 to 25 is strictly forbidden by German law, all vessels leaving Hamburg are watched by the police on this account.

There exists no Imperial Act regulating emigration matters, but almost all States have their local statutes, by which the transactions of emigration agents are supervised most carefully.

The following is an extract from the *Börsen Halle* of December 2, 1885:—

> "The local magistrate for the district of Aurich has informed all emigration agents within his district that such agents who distribute circulars inviting persons to emigrate, without having previously been requested to do so by persons wishing to emigrate, shall be deemed guilty of an illegal action, and if acting contrary to above instructions, shall lose their licenses. At the same time the agents are strictly ordered to abstain from taking part in any foreign colonisation scheme, and not to enter into any transaction for the purpose of obtaining emigrants for foreign countries."

The Imperial German Government has appointed an Imperial Commissioner, who has to supervise emigration from Germany, and who is stationed at Hamburg; this official has to make an annual report about emigration matters, which is to be laid before Parliament.

The normal increase to the population being about one per cent., the proportion of emigration is about one-third of the normal increase of the population.

It is impossible to leave this subject without remarking the great moral and physical good that has resulted from compulsory military service throughout Germany. The emigrants present signal examples of temperance, thrift, and energy.

The following letter from a gentleman high in the diplomatic service gives some interesting particulars as to German emigration :—

> "From 1876-80 the number of emigrants averaged 33,971 in each year, of which 8,465 went indirect, *i.e.*, from Hamburg to their destination through an intermediate port. In 1882, there were 113,221, of which 31,128 were indirect; 1883—89,465, of which 13,265 were indirect, and in 1884—91,603, of which 16,339 were indirect. The places to which these emigrants went were the United States, British North America, Mexico, Central America and West Indies, Brazil and the River Plate Republics, and other South American States, Africa, Asia, and Australia. In 1879, the number was 24,864, and in 1884—91,603. The two heaviest years were 1881-2, the numbers being 123,000 and 113,200 respectively. The emigrants are from all classes, the labouring class furnishing the largest contribution, and those without occupation coming next. The provinces of Pomerania, Prussia (East and West) and Schleswig-Holstein would appear to be the largest contributors. In 1884, of the total number of 75,264 direct emigrants, 71,843 went to the United States; 1,738 to Brazil, &c., 769 to Australia, 604 to other South American States, and 107 to Asia. Of persons over 10 years, in 1884, there were 45,638 male and 24,790 female, and from 1 to 10 years there were some 20,000. Of these, 33,059 were single men, 8,901 single females, and 14,206 families. The *raison d'être* for emigrating is difficult to say. The German authorities strenuously deny that the military system has any influence in promoting the desire, and quote in proof of this that the greater number of those going out of the country are time served men, but assert that the real *raison d'être* is to better themselves, and urge in proof of this, that large numbers of the labouring class, who, not being able to attain to the luxury of a cottage and plot of land here, say, 'We will emigrate.' Yet the figures quoted show a very large number of single men; of course, there are no means of verifying how many of these are time-served men. I have not the smallest hesitation in believing that the idea of rising in the social scale, and the magnificent will-o'-the-wisp idea of becoming a peasant proprietor, are two powerful motives in inducing them to emigrate, but without facts and figures, I cannot assert that military pressure—whatever I may believe—exercises any influence. I have known individual cases."

NORWAY.

There is a large relative emigration from Norway, which is mainly directed to the United States, to a very small degree to Canada, while none at all reaches the other English colonies. The principal cause is the want of agricultural employment, and the emigrants are therefore almost exclusively peasants and servant girls. Many of them are peasant proprietors, and realise the value of their small properties before leaving Norway, and do not, as is the case with a similar class in England, drift into the large towns. The population increases with considerable rapidity, but in Norway alone, among European countries, is the whole social question solved by emigration. There being no large towns, there is none of that magnetic attraction of a great mass which presents so difficult a problem in our own country. On the other hand, the standard of comfort throughout the country is lower than that prevailing in England, and there is, comparatively, no social or political discontent among the working classes.

There appears to be a general and intelligent understanding that the law of natural increase must be met by swarming to other hives, and not by political agitation for a re-adjustment of property. There is no discontent with the land system as it is, nor with the obligation to military service. Such pressure as does exist is that of want, and the minds of the people are not obscured by Socialistic teachings which inflame the residuum in countries of greater wealth.

The healthy character of Norwegian emigration is shown by the success attending the efforts of those who leave their country; secondary emigration being caused by those who, having succeeded in America, transmit funds to Norway, to enable their friends to join them in their new home; there is little or no pauper emigration, most of the people taking a little money with them. Their standard of comfort at home being low, they are not disappointed with the inevitable hardships and privations attending pioneer effort in a settlement; it may be added that there are few or no unemployed artisans.

EMIGRATION FROM NORWAY DURING THE YEARS, 1880-4.

	To America.	To other places.	Population of Norway.
1880	.. 20,212	.. 597	.. 1,910,000
1881	.. 25,976	.. 20	.. 1,915,000
1882	.. 28,804	.. 16	.. 1,913,000
1883	.. 22,167	.. 31	.. 1,914,000
1884	.. 14,776	.. 13	.. 1,923,000

The increase of population for the years 1881-4 was about 96,000, and the actual emigration for the same period, 91,803.

All emigration is under police control; each emigration and steam-ship agent gives securities for 20,000 körne, as a guarantee for good treatment on board ship; this deposit has occasionally been forfeited for misrepresentation, and from various causes, but it forms a substantial guarantee of the *bonâ fides* of the emigration agent, and for decency and good treatment on board ship. Before leaving, every emigrant has to appear before the police, in order to prove that he has satisfied the obligation of military service; the police also take an account of how much money the emigrant takes out of the country, and it may be well here to add, that the definition of emigrant in Norway is "a person who leaves his country to better himself, and who travels at a reduced rate, under regulations enacted and maintained by the police."

There are no private societies, nor any private enterprise, to promote emigration, the feeling of the people being so strongly in its favour. The attitude of the Government is somewhat hostile, and on a recent occasion the circulars of emigration agents have been stopped in the post.

The effort of Norwegian statesmen is directed towards the reduction of taxation, and thus to render emigration unnecessary. There is a graduated taxation on bachelors and married men; they are divided into four classes, and assessed for taxation in inverse proportion to the number of their families.

The Gothenburg system is now being tried in many small towns, and it is so great a success, that it came into force in Christiana in January, 1866.

The sobriety thus introduced into the habits of the Norwegians, which it is not too much to say has been induced by wise legislation, has seriously and favourably affected the character and qualifications of the emigrants.

HUNGARY.

The Hungarian Government deters emigration, by inducing migration to, and colonisation of, State lands, on which free schools and churches are given gratis; the payment for land is spread over fifteen years, and immunity from taxation granted for a similar period.

There is little or no distress among Hungarian peasantry, but there is considerable ignorance, and the consequence is that they have been misled by the statements of the beauty of America, and the facilities offered there for luxurious existence without the need of work. The increase in population is very small. Hungary is an agricultural country, and her interest, therefore, is in free trade.

The greater number of emigrants consists of indebted smaller country farmers, ruined by bad harvests and heavy State and communal taxes; the others are Jews, poor labourers, and a few town people, especially female servants. The causes of emigration in many cases are want of work, and in some parishes over population. Provisions against emigration are laid down in law, Article 38 of the year 1881. The title of this law is "Of the Emigrational Agencies." There is no way of directly prohibiting the emigration of citizens, but in the case when the emigrant has not yet fulfilled his obligation for military service — the Government finding that the greater number of emigrants do not leave their native country spontaneously, but are induced there by agents who buy up cheaply the little property of such emigrants, and only try to induce the largest possible number to emigrate, getting their commission on the number; on account of these reasons the legislature has devised measures against the agencies providing:—

> "That no one is allowed to enter into contract relating to emigration with people who want to emigrate, but those who are furnished by the Minister of the Interior with a license for agency.
>
> "Anybody acting as agent without license can for each act be punished with a fine not exceeding 300 florins, and with imprisonmeut for a period not exceeding two months."

Agents are not allowed to have any business intercourse with foreign agents or agencies without the license of the Minster of the Interior.

Agents are under the control of the authorities, and have to give notice of each case of emigration which has been negociated by them.

The contracting party can at any time withdraw his obligation, he only being bound to refund to the agent the out-of-pocket expenses incurred in drawing up the contract, as well as any sums advanced, and the eventual travelling expenses laid out for the party.

The agent can only be furnished with a license if he be a Hungarian subject. The Minister of the Interior can refuse to grant the license, even if the person requesting the right of agency answers to all requirements of the law, and he is also authorised to retract the license at any time. The licenses expire in one year, and must be renewed after the expiration of that period.

If evidence is furnished against an agent having commited fraud or deceit, or that he has meditated the emigration of such persons as have not yet fulfilled their military service, or of persons under age without the agreement of their parents or guardians, the whole of the caution money of the agent becomes at once forfeited.

POPULATION CENSUS, DECEMBER 31ST, 1880.

Male................	7,799,276
Female	7,939,192
Total	15,738,468

1881.	Births ..	604,262	Deaths ..	492,727
1882.	,, ..	708,011	,, ..	571,854

It is needless to give the results of inquiry in other European countries, as Germany, Norway, and Hungary each throw some light on the emigration question, and afford in certain particulars examples to imitate. While France is a warning to deter in everything that relates to colonisation, the standard work of M. Leroy Beaulieu, "De la Colonisation chez les peuples modernes" is an exhaustive and philosophic treatise on the causes of success and failure in the art of colonisation.

The practice of England herself is not without interest. While the State concerns itself with parental regard in seeing that "the statutory size of the emigrant's bed, as provided in the Passengers' Act, is carefully adhered to, it ignores the depredations of unprincipled people who, by dexterous evasion of the law, ruin the lives and destroy the hopes of thousands yearly. While the State is careful to ensure comfort and even luxury to the poor emigrant during his passage, she has hitherto neglected the more important question of advising as to his destination, and of care as to the *bona-fides* of the influences that have led him to quit his country.

If England cares little as to why the poor emigrant leaves the country, and is at no pains to equip him with the latest and best information, or to direct his courage and his energies into the best available channels, she is punctilious in assuring him provision of three tons of cubic space during his passage, and in seeing that the dietary scale provided by law is carried out.

The Passengers' Act of 1863 is now obsolete and needs revision. Under the shelter of its provisions astute and unprincipled men practise on the credulity of the poor, and actually convert provisions designed to protect the duly licensed passenger broker and his clients into the means of evading the law, and misleading, in the light of day, hundreds and thousands of ignorant and innocent victims. A few simple alterations would secure a marked improvement. Cases have occurred at the Mansion House police-court within a recent period, where complainants have sought advice from the magistrates as to means of obtaining redress for misstatements with reference to passages. As this law at present stands, the Board of Trade and the emigration officers acting under them, are powerless to assist the emigrants.

This difficulty arises from the 4th, 66th and 71st sections of the Passengers' Act of 1855. From the 4th section it will be seen that the Act never contemplated embarkation elsewhere than in the United Kingdom; and from the 66th and 71st sections it will be seen that the words "from the United Kingdom" raises a difficulty which cannot be got over.

Any future amendment of the Passengers' Act should follow the lines of the Netherland law on emigration, which, in Article 7, sets forth—

> "Any person undertaking either on his own account or as agent, to convey Dutch or foreign emigrants from the Netherlands, or a place out of Europe, shall, notwithstanding whether the embarkation takes place in a Netherland or a foreign port, previously provide real or personal bail, as a guarantee for the fulfilment of the conditions," &c.

Article 23 provides also that persons referred to in the first part of Article 7 should give security, &c.

Article 22 also prohibits persons who are qualified according to the Act, from advertising in newspapers, posting up bills, hanging out boards, &c., or taking any means whatever for making it known that they are emigrant agents; and giving the police authority to deal with such cases, is a wise precaution, and would put a stop to an immense amount of imposition being practised on emigrants.

Already our own colonial dependencies do more than half as much business with us in a year as all the rest of the world put together. In fourteen years the imports of British goods by our four largest colonies have nearly doubled, and if the same rate of progress be maintained, in twenty-one years the internal trade of the empire will be worth as much as the trade of the United Kingdom with the rest of the world.

Looking at the falling off in other directions, it would seem as though the colonies are the only quarters to which we can look with assurance for continued increase, and there is nothing so certain to stimulate that trade as a new and vigorous effort to create our own custom. In fact, the question is no longer whether we shall do it, but how is it to be done? and the line of least resistance to the desired end will assuredly be found in a new and cordial determination to understand the needs and to gratify the legitimate desires of our fellow subjects across the sea. Federation may be formulated by the politicians, but the essence and reality of federation must exist in the hearts of the people, or the word is but a tinkling cymbal and sounding brass.

It is needless precisely to estimate the money gain to Great Britain by the creation of a national scheme of emigration. Combined and fuller information collected in part, and distributed wholly by the State: the creation of a National Emigration Council; the provision of funds by the community; the adoption by the State of colonising schemes as alternatives to military measures; the guidance of British emigrants to British colonies, and the revision of the Passengers' Act of 1855, in accordance with the intentions of its framers, are measures which will increase our trade, knit our colonies more closely to the mother country, arrest the increase of the dangerous classes, by reducing the supply of competitors for unskilled work in the large towns, and thus contribute to the solution of the terrible social question which, looked at in the mass, is the dismay of statesmen and the despair of philanthropists.

DISCUSSION.

Hon. Sir CHAS. TUPPER, K.C.M.G., C.B. (High Commissioner for Canada), after expressing the pleasure it had given him to listen to the able paper, said he had not quite gathered the view which the author desired to place before them. He was at a loss to know whether or not Mr. White objected to State-aided emigration, as he seemed to take exception to the manner in which the subject of emigration was dealt with at present, and to question the ability of the various societies and agencies that were engaged in dealing with the subject to handle the question in an effective way. Mr. White proposed a federation of the various societies, but, unfortunately, he had told them that that had been tried, and a tentative method had been adopted, by inviting the various societies to come together, under the distinguished auspices of the Marquis of Lorne, but who nevertheless had failed in arriving at any common understanding. Therefore, he was at a loss to know how he national council was to be formed. How was it to be created? If the existing associations and societies now engaged in dealing with the question of emigration were not desirous of being federated, and having their associations united under a common head, the national council would only add another to the various societies, which, according to Mr. White, did not seem to be performing the work as efficiently as might be done. He believed that England owed a great deal to the existing emigration agencies, for the work performed by them had conferred a great boon, not only upon England, but upon the colonies, and this benefit the people of Canada were ready to acknowledge. Under these circumstances, he was not disposed to under-rate the exertions which had been made, though he quite agreed with the main principle that they had not proved to be adequate to the emergency. The question of emigration was of vital consequence, not only to the people of England, but to the British colonies; vital, as a means of relieving the congestion of over-population, and as forming great British colonies in Australia and other places, besides immensely increasing the trade of the country. He should hail with delight the adoption of any scheme which would tend to connect into a system the societies concerning themselves with emigration more completely than had been done, and to carry forward their work more effectually. He did not quite concur in the criticism which had been offered with regard to the want of information furnished to intending emigrants by the existing agencies, believing that London had the advantage of having within daily reach the very best sources of information that it was possible to have with regard to the British colonies and emigration. Knowing, as he did, the care that all his colleagues representing the other great colonies in this country felt they were bound to take and exercise in the dissemination of sound and correct information, he thought there was little left to be done in this respect. There was not an Agent-General in London who did not know that he would be inflicting the greatest injury he could upon his own country, and discrediting the great work of emigration, if he were to permit, so far as it was in his power to restrain it, the emigration of incompetent persons. So far from benefiting the colonies by inducing persons to emigrate who were not calculated to succeed, they would be doing them the greatest injury, and would be told of it at an early day. There was not only the desire to give, but full provision for doing so; the most reliable information was always available to intending emigrants at the offices of the Agents-General. No doubt there were were persons connected with the shipping agencies who were anxious to swell the numbers, upon whom perhaps they would receive a commission if they induced them to go abroad, but this influence was very small, and ought not to have much weight considering the sound and reliable information which had been placed within reach of all in London by the different colonies. Enormous as were the charities on behalf of emigration, he felt that the resources at command were not sufficient—it might be for want of systematisation—and the subject was one well calculated to demand, and to be entitled to, the cordial co operation of the State. Public money could be applied to no purpose more beneficial to England and to the outlying portions of the Empire than that of grappling with the great question of emigration. Indiscriminate emigration would be no advantage to England, and it would be a curse to the country to which the emigrants were sent; but appropriating public money to aid helpless (not idle or dissolute) industrious men to emigrate was not only justifiable, but was demanded in the best interests of the Empire itself. He trusted the time was not very far distant when a wisely-adjusted scheme would be devised, by which the State would do its duty in this matter, in conjunction with the philanthropic efforts of those who had already done so much, and under the supervision of the representatives of the colonies in London.

Hon. SIR SAUL SAMUEL, K.C.M.G. (Agent-General for New South Wales) said, after the very exhaustive paper to which they had listened, there was very little left for him to say, but there were just one or two points touched upon about which he might submit a few words. He would not discuss the scheme for the formation of a council, believing that, independently of such a council as had been suggested, much might be done to promote emigration to the colonies. He could not too often repeat that the greatest care should be taken, in promoting any scheme of emigration, that suitable persons only were sent to the colonies. No doubt England was suffering from great distress, but care should be taken that that distress was not transferred from her shores to the colonies. The colonies offered a fine field for emigration; and within the last two or three days he had received a letter from a man, who emigrated to Australia a few years since, stating that he was earning in Sydney £3 5s. a-week, as compared with £1 5s. which he earned in England, and forwarding money for five of his relatives to come out. That was a striking instance that if suitable persons were sent out they would find employment, and thus become consumers of the produce of England. A short time ago, a ship arrived in Sydney with 600 emigrants all of whom found ready employment, and 220 girls who were sent out found places waiting for them on arrival. There was ample employment for suitable persons, and, as the colonists were the best customers of Great Britain, it followed that the more persons sent out the greater would be the quantity of produce sent from this side. In Australia, people on the average consumed £8 per head of British manufactures, whereas in the United States they only consumed 10s. per head. With regard to the dissemination of information, he might say that his colony had emigration agents in every portion of the United Kingdom, and a large amount of literature on the subject was distributed. At present he had hundreds of applications from persons desiring to emigrate, and large sums of money had been remitted to him from people in the colony to send out their friends. The fact that this money was forthcoming was evidence of great prosperity. The other side of the picture was that a number of useless people were sent out who would not go out of the towns after getting to the colonies, and who, not being fitted for colonial life, did not get on. These men returned to England and spread the report that it was useless to emigrate, as there was no work to be obtained; although this was totally untrue. The question of emigration was a very large one, and might be discussed for hours, and various opinions were held upon it; but he must say was that if any one required information with regard to the colonies, they had only to apply to the Agents-General, who were at all times most happy to afford it.

Hon. Sir CHAS. MILLS, K.C.M.G. (Agent-General for Cape of Good Hope), regretted that, as he had come into the room late, he had not had an opportunity of hearing Mr. White's paper, but he felt sure that anything that gentleman had said upon a subject which he was so well able to deal with was worthy of the greatest possible attention. A great deal might be said upon the subject of emigration, though he was not prepared to enter into the sentiment of it. Taking a practical view of the subject, he might, however, say that one point was usually lost sight of by people in England, and that was the need for looking after emigrants upon their arrival in the colonies. In the Cape of Good Hope there was very little ground available for colonisation, but what there was could be purchased at a low figure, and as the climate was remarkably fine, any one who started with a little capital would assuredly prosper, provided he was sober and industrious. He had not yet received any instructions from his Government upon the emigration movement, but as a resolution had been passed that day at a meeting which he had attended, to the effect that an appeal should be made to the Colonial Government upon the subject, he had no doubt he should shortly receive instructions; and if any assistance was wanted by intending emigrants to the Cape, he should be most happy to give to the best of his ability such as it was in his power to afford.

Mr. WALTER PEACE agreed with Sir Charles Tupper that the question of emigration was one of vast importance to the British nation. He could not quite join with Mr. White in his recommendation that the National Emigration Council's duty should only be to collect informationtobe filtered through other societies.

Mr. ARNOLD WHITE explained that such was not his recommendation.

Mr. WALTER PEACE said he understood that was what Mr. White meant by the following passage:—"A national emigration council should by no means engage in the details of sending emigrants away. To do so would involve the creation of yet another competitor in the crowd of claimants for public money. The function of the council should be to receive funds from the public and distribute them impartially to societies and individuals who have proved themselves competent and economical in the transaction of previous emigration business." The fundamental idea was that this national council should not be a department of the State. He was sure that no one had thought more deeply upon this subject than himself; it had been to him like meat and drink for some years past, and there was a fascination in the subject as dealing with the present and future prospects of one's fellow-creatures. It was in that spirit that every Agent-General conducted his operations, and it was for that reason that confidence might be placed in their representations. He believed the day would speedily come when the British Government would admit the necessity of a national scheme of emigration as being the best means for promoting British commerce, and would devote funds towards carrying out the scheme. Hitherto, emigration had been conducted at the expense of the Colonial Governments, but the time had now arrived when it was equally necessary for the Government of Great Britain to spend money in helping men to the shores of the colonies, and he hoped pressure would be continually brought to bear upon the Government, so that the scheme might be placed within the region of practical politics, and successfully carried out.

Hon. Major ERSKINE (late Colonial Secretary for Natal) said that having been connected for many years with the colony of Natal, he should have been glad to offer a few observations, but as the subject required to be thought over, he did not like to commit himself without consideration. He was deeply grateful to Mr. White for the observations which he had made, and having listened to the observations of previous speakers, he had received much instruction from them. There was no more difficult question than that of emigration to Natal, owing to the competition in the labour market. It was useless for any person to go to Natal with the idea of merely becoming a labourer. In order to succeed in that colony, a man must have a certain amount of capital as well as fitness. He was convinced that gold mining in South Africa was going to be a great success, and that as the coal bearing strata in that country extended 1,500 miles right up to the Zambesi, there was a great future for Natal, as food would have to be provided there in order to supply the gold miners. It was a mere question of time with Natal as to its thriving.

The Hon. JAMES F. GARRICK, C.M.G., Q.C. (Agent-General for Queensland), thanked the author of the paper for having pointed clearly to the sort of persons who were the most desirable colonists, viz., those who were able and willing to work. It was perfectly useless for persons to go to the colonies who were either infirm or idle, because they would do no better upon the other side of the globe than they had done upon this. It was simply to transfer a malady from one place to another, and the malady would become more acute in the colony than it had been found in this country. He thought Mr. White had left something out of the scheme without which it would be quite incomplete, namely, a system of State emigration. No money could have been better spent than in colonising the the possessions of England, and the reader of the paper had himself pointed to an instance in South Africa where, if a few thousand pounds had been spent in colonising purposes, it would have this day day saved the expenditure of some millions for warlike purposes. Looking at the title of the paper, he was prepared to think that the word "national" implied not only a system of emigration supported by the colonies, but by the British Government. He should fail in his duty as the representative of Queensland if he did not refer to the efforts which had been made by that colony for taking people from England, and placing them in Queensland. The colony had spent, from the pockets of its tax-payers, on emigration purposes, £2,600,000. Within the last five years they had spent £1,300,000 in sending people there, and they were now spending £250,000 every year, for the purpose of sending out emigrants. During the last five years, 67,000 people had been sent out. When it was recollected that the colony commenced with 25,000 people, it must be acknowledged that they had seen the benefits of emigration, for, in the year 1883, nearly 40,000 people were taken out. No doubt the chief matter to be considered was, that the right class of people were selected, and he could support in the strongest terms what had been said upon that subject by Mr. White. It was there the danger came in of the societies to which reference had been made; they had not control and grip enough of the whole thing in order to send out the right sort of people. It had taken his colony nearly twenty years to get that grip, and they did not now intend to hand over that grip to the charge of someone else. Mr. White had said that the means of information at the command of intending emigrants was imperfect; but all he could say upon this point was that there was scarcely a town or village in the three kingdoms where Queensland had not an agent, and also lecturers who were most anxious to give reliable information. The value of sending out proper persons was not only to be found in the fact that the over-pressure in England was relieved, but that customers were obtained for English produce, who took at least twelve times as much of British productions as any foreigner. As reference had been made to the large loans to the colonies, it should not be forgotten that these loans went a great way in giving employment to people on both sides.

Mr. F. YOUNG (Secretary of the Colonial Institute) wished, in common with the other speakers, to thank Mr. White for the valuable contribution which he had made to this great and important question. The subject was one which must be faced as a national question. Many years ago, in that room he had the privilege and honour of speaking upon the subject, and after many years experience he could only reiterate the sentiments he had then expressed, viz., that the question must be taken up by the Government as a national one, as it was too great a subject to left to private enterprise. It was necessary in framing a national scheme of emigration, or colonisation as he preferred to call it, that it must be placed in the hands of those who were competent to carry out such a scheme in the most successful manner. One of the great obstacles to undertaking it on this side of the water was the natural jealousy which the colonists might feel that it was the wish on this side to send out at any price the surplus population, which it was not desirable to detain here. He was one of those who considered that England could afford to send away a large number of the surplus population without sending the dregs. As had been already said, people on this side ought not to think their duty complete with the mere shipment of the emigrants, but should look after them upon their arrival, until they were put in the way of becoming successful. The time had now arrived for the British Government to do its duty in helping the colonies upon this matter, and he hoped that no further time would be lost.

The CHAIRMAN, in closing the discussion, said the matter had been taken up chiefly as one of assisted emigration without reference to the great amount of emigration which had taken place through private enterprise. The Agents-General could only give their valuable advice and assistance, as they did, but they were not responsible for the impulses which induced persons to go out to the colonies. Many emigrants turned out well, while others turned out loafers, and caused a great deal of trouble in the colonies, as well as in the United States. He happened to know, through the St. George's Society here, in connexion with the North American Union of the St. George's Societies of Canada and the United States, that it was thought by them there was an organised scheme for sending out paupers, but, as was well known here, the number of paupers sent out was extremely small. One of the first things done by the societies there, in the great cities of Canada and the Union, upon the arrival of emigrants, was to give valuable advice and assistance on the spot. He was surprised that while this had been found so successful in Canada, there was no such society in Australia, or even in South Africa. There was a St. Andrew's Society in some places, but not a St. George's Society. There was one point which had not yet been touched upon, namely, that in directing a national system of emigration, in which the State should take its part, the question of reproductive emigration should be considered. This he had advocated many years ago. Such considerable amounts were sent by the Irish from the United States as to have been a subject of complaint in the American press. Large sums were remitted annually to the Agent-Generals by persons in the colonies for the purpose of sending out their relatives, and all this proved that there was a reproductive element available. He had never been able to see why, if the colony of Queensland made an advance to a man for his passage and outfit, this money should not be returned when the emigrant became successful, and he hoped that when there was a federation of the Australian colonies, the subject would be considered, and means taken for a general law in all the colonies for recovery of advances to emigrants, and for remedy for ill-treatment of emigrants on board ship. The assisted emigrant was not on the footing of the man who went out at his own expense, except in getting the same advantages. Very often a man had pledged himself to pay for his passage and outfit; he removed to another colony, and there was then no means of recovering the money lent. It would be possible for the colonists to assist in that and other ways. It was not necessary that there should be any very large payments from the national exchequer; on the contrary, any sums provided should be simply in the nature of temporary advances, raised in the market on exchequer bills, and recoverable. Why should persons go to Canada, South Africa, and other places, to reap great advantages at the public expense, and give no personal return? It was true, as had been said by other speakers, that there was a large indirect return by the consumption of manufactures, but this was not all that was required. If the colonies were to co-operate in any Imperial system, they would get a great advantage in emigration over the United States. They were much in the habit of complaining of emigration to the United States, and it was but natural that many people should go to that region, which held so large a majority of the hundred millions of English-speaking people, but it was desirable to induce Englishmen to emigrate to the colonies rather than to the United States. It was reckoned that the cost of sending out a soldier to India was £100—and this person could not be looked upon as a productive consumer On the other hand, a man sent to the colony at the expense of £10 would, during the whole course of his life, become a consumer to the extent of £10 every year, and so would his children. The more the subject was discussed, the more it would be seen that there was no real difficulty, and that there were very great benefits to be at once derived. With regard to one statement by Mr. White as to emigration from Germany being quickened on account of the dislike of Jews to military services, it must not be forgotten that the Jews had taken their part in the late wars as well as any other class, many members of that faith having left London for the purpose of performing military duty during the recent conflict, and in France the same thing had taken place. In conclusion, he proposed a hearty vote of thanks to Mr. White.

Mr. ARNOLD WHITE, in acknowledging the vote, said that reference had been made to the desirability of State aid, and he agreed with the remarks upon this subject, but it must not be forgotten that England with a £100,000,000 Budget this year, and the same next year, was about as much likely to contribute to State emigration as it was to State confectionery. Therefore he thought gentlemen should address themselves to what was practicable, rather than to what was desirable. Reflection had been made upon the failure of the Federation Society last year, but that surely was one reason for again taking up the question. With regard to the dissemination of information by Agents-General, it must not be forgotten that there were only ten Agents General in England, and as it was impossible for poor men in country places to communicate with them, it was desirable that some means should be devised for focussing the means of information. As some of the parts of the scheme proposed in the paper had not been touched upon in the discussion, he presumed that the different speakers so far agreed with what had been proposed. Mr. Garrick referred to a national and Imperial scheme of emigration, but it should not be forgotten that the Agents-General were ambassadors of the wage earners in the colonies, and the question of interest was as great for the exclusion of English workmen as of the Chinese, so that the scheme suggested, although very charming, was not likely to be fulfilled. He agreed with the suggestion thrown out by the Chairman that means should be devised for the return of funds advanced to emigrants, and he believed that plenty of money would be provided for all purposes if people could be assured that the money would not be spent on unnecessary machinery.

The following communication has been received from Mr. STEPHEN BOURNE :—

" He would have been glad had there been time to have said a few words on the home side of the question. It would be in the recollection of some now in the room that, several years ago, both at the Colonial Institute and elsewhere, he had strongly advocated " extended colonisation to be a necessity for the mother country." He had, at the same time, expressed his opinion that this necessity would not be fully met without the aid of State-supported emigration. On the side of the colonists, it must not be considered that there was an act of charity towards the mother country in relieving her congestion, but as the reception of so much capital, in the shape of muscle, bone, and brain, to be employed for their mutual benefit. Some years since it was estimated by Dr. Farr that the breeding and training of each emigrant must cost the country £15. It could not now be put at a lower figure than £25 per head. For the investment of this capital in her daughter's fields, the mother must look for some return; and this should be found in the markets she created for her wares. Of course those who chose to emigrate entirely at their own expense would be free to select whatever land they preferred for new homes; but neither State nor philanthropic funds could be bestowed on emigration to foreign lands without robbing the mother country of the return she had a right to expect. More than this, it would be necessary to see that in these new spheres of labour the emigrants would not be rivals or competitors of the manufacturing interests at home. Their proper position was to develop the natural productions of the lands in which they settled, and to leave alone any other industries until they were at least able to prosecute them without the aid of protective duties, on imports from home. The destination of such migrants, therefore, should neither be to foreign countries at all, nor to any portions of the Empire which did not accord to us at home perfect freedom of trade. Their aim should be to arrest the movements from country to town on either side—to promote that from country here to country there. It was important too, as advised by Mr. White, that those who went out should be abstainers. Mr. Bourne would not discuss or criticise the national council which Mr. White proposed, because he did not see that our statesmen were yet alive to the paramount necessity of, in some way or other, providing for the emergencies which arose from the joint action of increasing population at home and decaying markets abroad for our manufactures. The ever-growing preponderance of imports over exports was teaching lessons which were being only slowly learnt, and he feared this would have to proceed to a yet greater extent before the nation awoke to its peril. In the meantime circumstances might alter the form of organised effort to promote the great object both lecturer and speakers wished to advance. That object was, in fact, enlarging the area of the United Kingdom, which our minds were fully set upon accomplishing. The methods which it was best to set in motion would have to be settled according as the exigencies of the period might suggest or render advisable. Mr. White now unwittingly exaggerated the growth in our trade with the colonies from not being aware that in the accounts for the earlier of the two years he had brought into comparison, a large quantity of goods which underwent transhipment, as, for instance, at Suez and Portland—on their way to India and Canada—were credited to the country of first arrival instead of to that of ultimate destination. All such papers and discussions as they had that night were powerful aids to progress, and he felt that thanks were due to Mr. Arnold White for the successful way in which he had brought the subject forward."

EIGHTH ORDINARY MEETING.

Wednesday, Jan. 27th, 1886; Sir FREDERICK BRAMWELL, F.R.S., Pres.Inst.C.E., Vice-President of the Society, in the chair.

The following candidates were proposed for election as members of the Society:—

Blagden, William George, 1, Fenchurch-avenue, E.C.
Blair, John, Elmslie, Kilmarnock.
Hudson, John G., 18, Aytoun-road, Glasgow.
Morice, Beaumont, LL.B., 2, Garden-court, Temple, E.C., and Treffiys, Erith, Kent.
Pogson, William Norman, Nungumbauhum, Madras.
Robinson, Walter, Forehill, Ely.
Short, John Young, 49, West Sunniside, Sunderland.
Smith, Fred Snow, Yeadon, near Leeds.
Trubshaw, Charles, Midland Railway Company, Derby.

The following candidates were balloted for and duly elected members of the Society:—

Aldwinckle, Thomas William, 2, East India-avenue, Leadenhall-street, E.C.
Atkins, Alfred, Wanganui, New Zealand.
Beadel, William James, M.P., Springfield Lyons, Chelmsford, Essex, and 97, Gresham-street, E.C.
Bedford, Alfred, Waltham-buildings, Holborn-circus, E.C.
Brindle, Thomas, North-bank, Tunbridge Wells.
Criswick, George Stickland, F.R.A.S., Royal Observatory, Greenwich, S.E.
Grahame, Harry, Wanganui, New Zealand.
Kennedy, Thomas, 11, Old Jewry-chambers, E.C., and 61, Warwick-road, Earl's court, S.W.
Kirkwood, W. G., Stowford, Mowbray-road, Upper Norwood, S.E.
Lee, Herbert Cabry, 9, Park-crescent, Portland-place, W., The Brewery, Hill-street, Peckham, S.E.
Lyle, Charles, 37, Mincing-lane, E.C.
Medley, Dudley Julius, B.A., Keble College, Oxford.
Milnes, William Stert, Woodstock, Grove-park, Lee, S.E.
Mumford, William Thomas, 36, Oswald-street, Glasgow.
Pain, William, 8, Adelphi-terrace, W.C.
Porter, Nicholas Ellis, 2, Belgrave-terrace, Lee, S.E., and 101, Leadenhall-street, E.C.
Pownall, Robert, Wanganui, New Zealand.
Richards, James, 9, The Chase, Clapham-common, S.W.
Rosenheim, Herman, Highfield-house, Fitzjohn-avenue, N.W.
Turle, Edward, Wimbledon School, Wimbledon.
Yglesias, Miguel, 2, Tokenhouse-buildings, E.C.

The paper read was—

MACHINERY IN MINES.

By HENRY DAVEY, M.INST.C.E.

Mines were the cradle of the steam-engine, and the drainage of mines the necessity which gave birth to the invention. The Marquis of Worcester, in 1660, in his "Century of Inventions," speaking of his engine, of which there remains no clear or authentic description, says:—"And I may boldly call it the most stupendous work in the whole world, not only with little charge to drain all sorts of mines, &c." In the records of the Royal Society of 1699, it is recorded that Mr. Thomas Savery entertained the Society with showing his "engine to raise water by the force of fire." Savery published a description of his engine, and called it the "Miner's Friend." Savery's first engine was erected at Wheal Vor, in Cornwall. In 1705, Newcomen, seeing that the miner's wants were not yet fully satisfied, succeeded in advancing a step further. Newcomen's engine was studied by Watt, whose great genius led him to the invention of the separate condenser, the greatest single advance in the history of the steam-engine.

It will be interesting, before we describe the more modern improvements in pumping engines for mines—improvements more in matter of detail than in general principles—to briefly describe the early development of the engine. It will help us to fix the mind on the salient points of the subject.

Savery's engine consisted of two vessels connected to a boiler by pipes and cocks, so arranged that by opening and closing the cocks in regular order, and at intervals, the vessels were first filled with steam, and then with water, the water rising into the vessel by atmospheric pressure as the steam became condensed. The pulsometer of the present day is a Savery engine made automatic in its action.

Newcomen employed the atmospheric pressure to raise the water by means of a steam cylinder and piston, made to actuate a pump by means of a beam, by first admitting steam into the cylinder to raise the piston, and then injecting water into the cylinder to condense the steam, thereby causing a vacuum under the piston, which descended by atmospheric pressure, and in doing so lifted the water in the pump. Watt used Newcomen's cylinder and piston, but condensed the steam in a separate vessel, and instituted expansive working, leaving for his followers the further development of those principles.

During Watt's time expansive working was not carried to a large extent. His engine worked bucket pumps, a condition not admitting of a high degree of expansion. It was not till the introduction of the plunger pump into the Cornish mines that the Watt engine was capable of working with considerable expansion. It was the substitution of the plunger for the bucket pump that constituted the change from the Watt to the Cornish engine, and was the chief cause in raising the duty from 20 to 60, and in some cases to 80 or 90 millions of pounds raised one foot high by the consumption of one cwt. of coal. Watt left Cornwall in 1800. The duty of his best engine was then 20 millions.

In the Watt engine, the water in the pump was lifted by the direct action of the steam on the piston of the engine, the return stroke being performed by the weight of the pump rods. This condition of things did not admit of a great range of expansion. In expansive working, the pressure on the piston towards the end of the stroke is less than the resistance of the pump. It is, therefore, necessary that a considerable mass should be attached to the piston to absorb energy by its inertia at the beginning of the stroke, and to give out that energy by momentum towards the end of the stroke. That function is performed in the rotative engine by the fly-wheel, and in the reciprocating engine by the piston and its attachments. The attachments of the piston of the Watt engine were comparatively of little weight, but when the change was made from the bucket to the plunger pump, it became necessary to employ very heavy pump rods, because the action of the pump was reversed, and the weight of the pump rods was then used to overcome the resistance of the pump, instead of, as in the former case, the passive resistance of the engine on the idle stroke. The plunger pump was introduced purely as an improvement in the pump work, but after it was introduced, it was found that Watt's engines could be worked more expansively, and their efficiency raised in consequence. Many Cornish engines have as much as 200 tons of pump rods attached to them. With such a reciprocating mass, a high degree of expansion is practicable and easy. There are hundreds of so-called Cornish engines put up without any attempt to work them expansively, but such engines are not Cornish engines; they are Boulton and Watt engines of the earliest and crudest form. The reputation of the Cornish engine rests on its proper application, a fact which is often overlooked.

In "Lean's Historical Statement of the Steam-engines in Cornwall," published in 1838, Mr. Lean says:—

> "About the year 1801 the author's father, Captain Joel Lean, who besides being an experienced and intelligent miner was a good practical engineer, was appointed principal manager of Crenver and Oatfield, in the parish of Crowan, one of the best and most extensive mines then at work in the county. He found the engines and pit work in a very bad condition. The mines were about 170 fathoms deep from the surface, and 140 fathoms below the adit, and the water was drained by three steam-engines, namely, a 63 in. cylinder-double on Bull's mode of construction, having the cylinder over the shaft, and a piston rod working through its bottom; and a 60 in. and 36 in. cylinder-single cylinder engines on Boulton and Watt's plan. The consumption of coals by these two engines was enormous, and the average duty under ten millions. Bull's engine, 63 in. double, consumed fourteen cauldrons of coal in one day. The pit work too, which consisted of leathern buckets, with two or three pistons, such as were at that time in general use for plungers, was in a very bad state, and it may be safely asserted that the engines were idle at least one-third of the time, repairing the pit work and changing the buckets."

After he had assumed the management, Captain Lean's attention was immediately directed to the pit work, and here he first introduced what is now so generally used, and with so great advantage, the plunger pole, instead of the common buckets and piston, wherever he found it practicable.

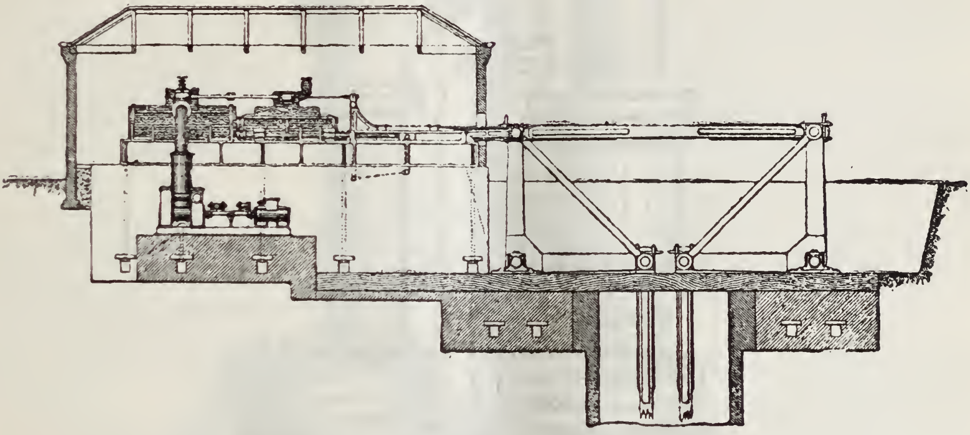
It is a curious fact, that although the plunger pump has been almost universal in Cornwall for the last fifty years, it has, until lately, been little adopted in collieries. It is usually employed to force the water 40 fathoms only, so that in a shaft 200 fathoms deep there would be five pumps, lifting the water from the bottom in stages, from one to the other. The lowest pump is usually a bucket pump, for convenience of sinking. Stage pumping is often convenient where feeders of water occur in the shaft at different levels, because, as a question of power, it is more economical to pump the water from where it is found, instead of letting it run to the bottom of the mine, and pumping it from there; but stage pumping is generally very troublesome, and requires very careful supervision. It becomes necessary to have a pipe from one pump to the next pump below it, so that the water may be run down to keep all the pumps equally charged under the varying conditions of wear and tear. Trained men are kept for this and the other work connected with the pumps. In Cornwall they are called pitmen, and in the north of England pump doctors.

The plunger pump has, of late years, been so improved in form, that it may be safely employed to pump water even as high as 200 fathoms in one direct lift, so that, as far as the pumps are concerned, the necessity does not remain for stage pumping. The old form of plunger pump was not suitable for pumping to a great height in one lift. It was weak in form, and inconvenient of access to the valves, and involved risk of life to the pitmen, because all the operations of changing valves and repairs to the pump had to be done in the shaft. The modern and most approved method of draining mines economically, without risk of flooding, is to have two pumping engines, each capable of draining the mine, and provided with plunger pumps.

In the Cornish engine the practical limit of expansive working is soon reached. Not so in the compound engine; and as the compound engine is double-acting, and the Cornish engine necessarily single-acting (when worked expansively), the compound has distinct advantages, both as regards power and economy. Of late years the compound engine has met with a large application in mines. Here the author would observe that the double-acting non-rotative beam engine is not a Cornish engine, though often so called.

As a recent example of heavy pumping performed by a compound engine, with the improved plunger pumps before described, the author selects one of the engines recently erected by the South Staffordshire Mines Drainage Commissioners. This engine will raise 4,000,000 gallons per day from a depth of 600 feet. That is to say, it would fill this room with water, and lift it one and a half times the height of the cross of St. Paul's, every hour. It has cylinders 52 in. and 90 in. diameter, by 10 ft. stroke, and works 27-in. diameter plunger pumps, 10 ft. stroke, equal in power to a 120-in. Cornish engine.

Fig. 1.



Horizontal Engine and Double Ram Pumps.

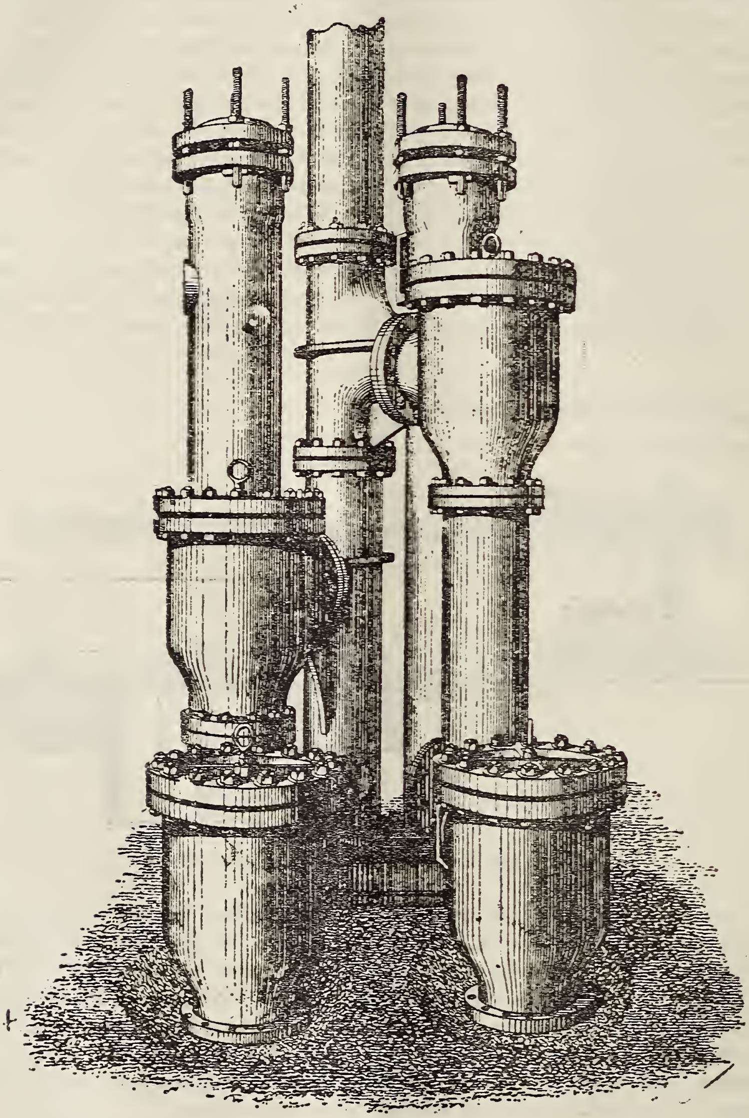
It is not unusual to find in collieries as much as six tons of water to one ton of coal—that is to say, there are collieries raising say 6,000 tons of coal per week and 36,000 tons of water in the same time.

Underground Pumping Engines.

The conditions of mining vary so much that it is impossible to frame any general rules as to the type of machine which is best suited to any particular mining operation. The old form of pumps, worked from spear rods, as we have before seen, gave considerable trouble, and involved costly maintenance; considerations which favoured the introduction of underground pumping engines.

In underground pumping engines, the engine and pump are combined in one self-contained machine, employed to force the water from the position in which it is placed in the workings, direct to the surface through a single pipe. Sometimes the boilers for working the engine have been placed in the workings near the engine, but generally steam has been taken down through a pipe from boilers situated on the surface. It is seldom that very heavy pumping is performed on this plan. In many situations it is convenient and desirable, but in an economical point of view there is a serious loss by condensation in conveying steam down the pit. Wherever this plan is employed, care should be taken to dry the steam as much as possible before it enters the cylinders of the engine.

Fig. 2.



Improved Plunger Pumps.

The author would here emphasise the fact that there is no greater impediment to steam-engine economy than the presence of water in the steam, or what is practically called "wet steam," either arising from priming of the boilers or from subsequent condensation in the steam pipes.

Steam is often conveyed down the mine for the purpose of working, not only the pumping machinery, but also the hauling engines; but since the introduction of compressed air machinery the practice is not so usual.

About ten years ago the author erected, at the Clay Cross Collieries, a pair of underground engines to force water 1,000 ft. in one direct lift, and experiments were then made to determine the loss by condensation in taking steam down the pit.

RESULT OF EXPERIMENT TO ASCERTAIN THE LOSS CAUSED BY TAKING STEAM DOWN A COAL PIT.

Diameter of pipes	7½ in.
Vertical height of do. in pit	915 ft.
Horizontal length on the surface....	185 ,,
Total length	1,100 ,,
Length of pipes with non-conducting cement	1,015 ,,
Length of pipes unclothed	85 ,,
Pressure of steam at surface ..	45 lbs. per sq. in.
Pressure of steam at pit bottom when engines were standing	46 lbs. ,,

The engines consisted of a pair of single-cylinder direct-acting engines:—

Diameter of cylinders	20 in.
Length of stroke	36 ,,
Speed of engines..	10 double strokes per minute.
Water from condensation in the pipes	12 cubic feet per hour.
Water from condensation when the engines were standing	8 ,, ,,

The steam pipes stood on a strong piece of timber at the pit bottom, and were kept in a vertical position by stays fixed 27 ft. apart, vertically. An expansion joint was provided near the top, and the expansion of the pipes was found to be 18 in., or 2 in. for every 100 ft. in length.

TRANSMISSION OF POWER.

The underground workings of mines extend to great distances, and cover large areas. The roads are often miles in extent, necessitating a very large application of power. Manual power (except in the actual excavating of the minerals) was first supplemented by horses, and is now almost entirely superseded by machinery. The miner has been assisted by the engineer, and his labour rendered less irksome and less dangerous.

Compressed air forms a very convenient medium for actuating underground machinery, and is extensively used for working hauling engines. Mechanically speaking, it is not economical; but as long as it is commercially profitable, there is a great incentive to the engineer to increase, if possible, the efficiency of its application. The general practical efficiency is from 25 to 33 per cent. of the power applied.

The following results of experiments made with a pair of air compressors working underground hauling-engines, are of interest, and highly instructive, and fully demonstrate the increasing loss of efficiency with the increasing pressure to which the air is compressed:—

When the air was compressed to 54 lbs. per square inch, the total efficiency amounted to only 14·27 per cent., but when the pressure of compression was reduced to 40 lbs. per square inch, the total efficiency rose to 24·42 per cent.

The experiments were conducted under precisely similar conditions, but the low efficiency in both cases is accounted for by the fact that the hauling engine did not use the air expansively.

The utilised power in the steam-engine, as ascertained from the steam and air indicator diagrams, was 87·25 per cent. in the first case, and 85·62 per cent. in the second. As all other things were equal, the lower efficiency resulted from the increased heat formed by the higher compression.

The loss of power arose from the cooling of the air after compression, before reaching the hauling engines, and the want of expansion of air in the hauling cylinders. It has often been pointed out that the loss from cooling might be partially restored by heating the air before it enters the hauling cylinders, but the author has not met with a practical application of the idea.

Hydraulic power has been used to a considerable extent for the transmission of power in mines, especially for raising water from the lower workings to the pumps of the main pumping engine, and in some cases actually pumping the main water feeders of the mine. It has also been used for working hauling engines.

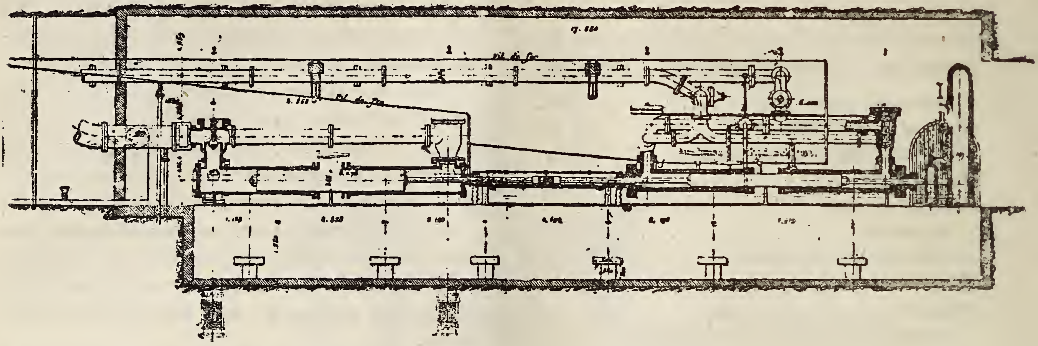
An interesting example of such an application has been recently instituted at Marseilles, in a colliery belonging to the Société Anonyme de Charbonnages des Bouches-dû-Rhone. M. Biver, the engineer of the mine, has since the completion of the installation carried out careful experiments, the results of which he has published in "Le Genie Civil," and from it author has extracted the following facts:—

The installation is specially interesting, as it was designed to meet special difficulties. The portion of the workings to be drained was subject to periodical inundations. It was therefore out of the question to think of employing underground steam-engines. It was also impossible to employ pumps in the shaft, already fully occupied with pump rods and winding cages.

M. Biver requested the author's firm to prepare a scheme to meet the special difficulties of the case. The scheme proposed by the author was that of hydraulic transmission from the surface.

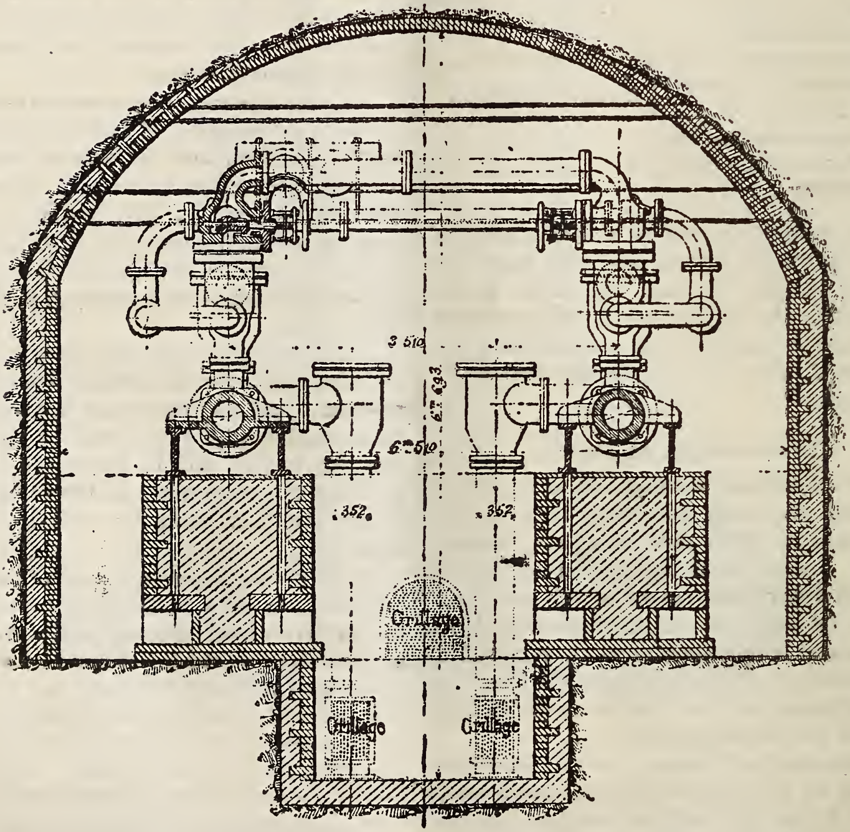
In a gallery which is subject to inundations are placed two hydraulic pumping engines, delivering the water which they pump into the drainage gallery of the mine some distance

FIG. 3.



HYDRAULIC PUMPING ENGINE.—LONGITUDINAL SECTION.

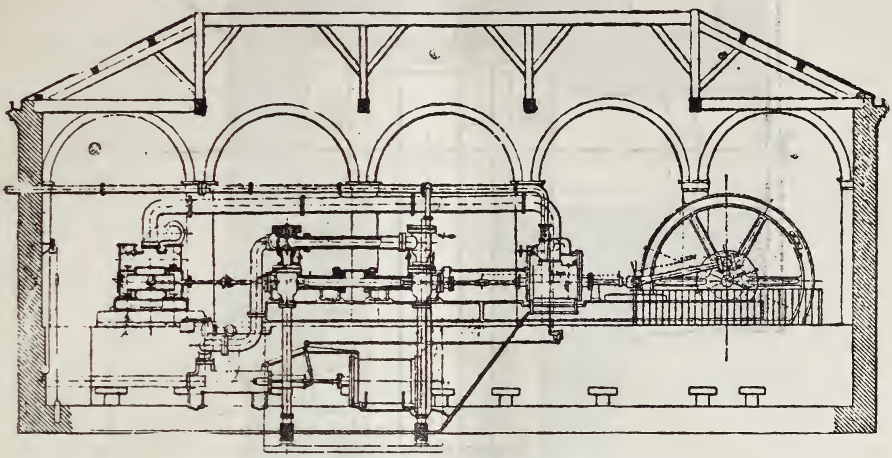
FIG. 4.



HYDRAULIC PUMPING ENGINE.—TRANSVERSE SECTION.

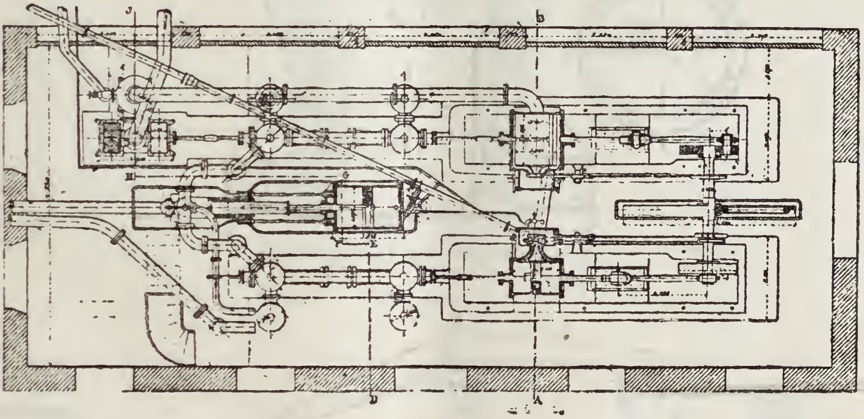
below the surface. At the surface of the mine is placed a compound condensing pumping engine, actuating two double-acting pumps, from which water is conveyed at a pressure of 42 atmospheres direct to the hydraulic pumps. The water supplying the hydraulic pumps is not discharged into the mine, but returns again through a second pipe to the pumping engine (or heart of the system) on the surface; so that the water which actuates the hydraulic engines simply circulates through the system by means of a supply and return pipe, just as blood in the veins of a human being returns to the heart to be pumped, over and over again.

Fig. 5.



Compound Condensing Pumping Engine.—Longitudinal Section.

Fig. 6.



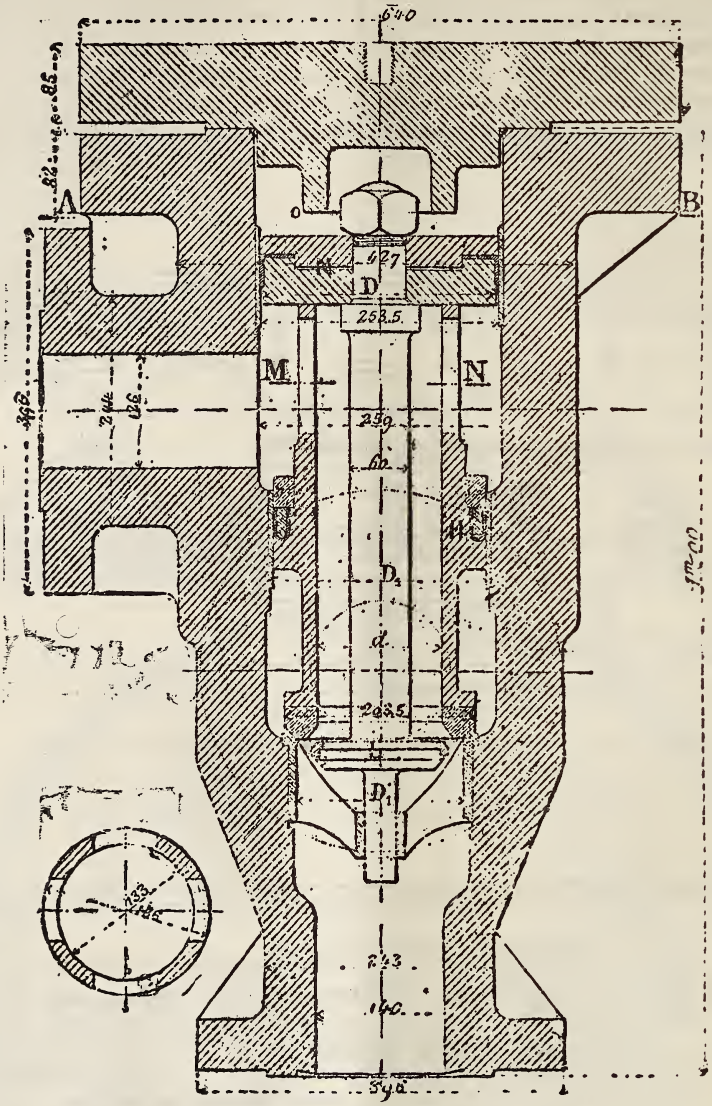
Compound Condensing Pumping Engine.—Plan.

It is evident that there is a back pressure on the hydraulic engines, due to the vertical head of water in the return pipe. The effective pressure is the pressure produced by the pumping engine on the surface.

In Sir William Armstrong's system of hydraulic transmission, the pumping engine delivers its water into an accumulator, from which power is distributed. The accumulator is here introduced to store the power of the prime mover, and to meet the interrupted demand for power caused by the intermittent use of the hydraulic machinery.

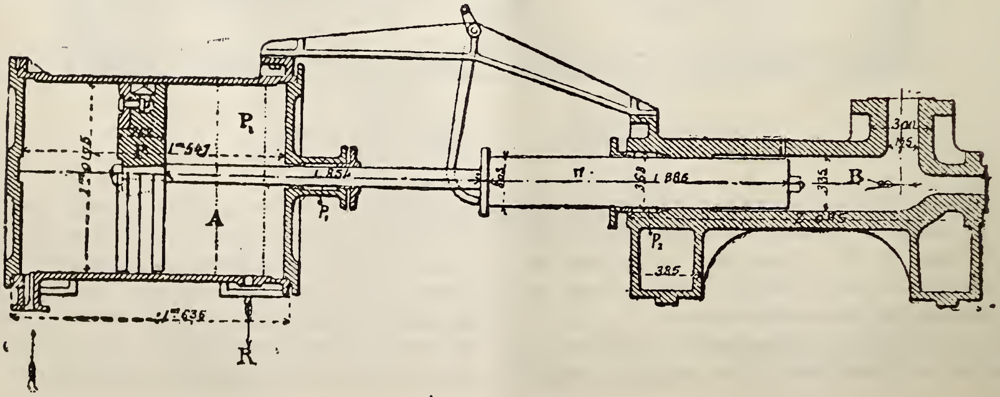
In the case under notice the use of the hy-

Fig. 7.



Arrangement for Distribution.

Fig. 8.



Accumulator.

draulic pumps is constant; there was, therefore, no object in storing power. The main desideratum was to cause the hydraulic pumps to respond directly to the motion of the engine on the surface, so that the speed of the engine on the surface should give the speed at which the hydraulic engines were working underground. It will easily be seen that if the pumping engine on the surface delivered a constant stream, and the hydraulic engines below used a constant stream, there would be no necessity for anything between the two engines than a closed pipe; but both engines have a reciprocating action, and, therefore, produce an intermittent stream in the pipe. To correct this intermittent action, and to preserve a constant pressure, and to maintain the engines working in unison, the author devised the steam regulator. The regulator simply consists of a plunger in direct communication with a pipe connected to a steam piston, on the face of which is maintained a constant steam pressure. The pressure of the steam on the piston, multiplied into its area, being equal to the re-acting pressure on the plunger multiplied into this area, there is, therefore, a balance of forces. Any rise in pressure in the supply pipe, arising from intermittent action of either of the engines, causes the plunger to move downwards, and therefore increase the capacity of the pipe, and *vice versa*, whenever reduction of pressure occurs. The movement, then, of the steam regulator, is to preserve a constant pressure by varying the capacity of the pipe. It also serves the double purpose of a governor on the steam-engine. The throttle valve of the steam-engine is connected directly to the piston of the steam regulator. A little thought will enable one to see that a dead weight on the plunger, instead of steam pressure, would not have the same effect. The inertia of the weight would cause heavy shocks in the pipes. The weight of steam is so much less than its pressure that its inertia may be neglected.

It would occupy too much time to go further into mechanical details; the author simply gives the results of actual working, according to the tests which have been made. M. Biver has carefully taken indicator diagrams from the steam-engines, the pumps, and the hydraulic engines, and has measured the quantity of water pumped. The following are the results of his observations:—

Pressure in supply pipe at the prime mover..	42 am.
,, ,, ,, hydraulic pump	57 ,,
Pressure in return pipe ,, ,, ,,	15 am
No. of revolutions of prime mover..	22
No. of double strokes of hydraulic pumps ..	5·12

The total efficiency of the whole system reaches 54·2 per cent., and the consumption of steam amounts to 13·76 kilogrammes per horse-power in water pumped. The author predicted a consumption of 13·60 kilogrammes. The total horse-power exerted by the steam-engine was 229·2 horse-power, and the work actually done by the hydraulic engines 124·2 horse-power. The total cost of the whole installation, including buildings, excavations, and all other matters, amounts to 215,771 francs. It is intended to increase the speed of the prime mover, and thereby obtain additional power for working pumps in the dip workings, and also for working a pair of hauling engines.

Ventilating Machinery.

In metalliferous mines there are generally several shafts; the shaft in which the pumps are fixed is usually called the engine shaft Where there are two or more shafts communicating with the workings, it is a curious fact that a very considerable amount of natural ventilation takes place without any machinery or appliances whatever. If we take a lamp chimney and put in it a vertical division extending some distance down from the top, dividing the cross section of the chimney into two parts, we shall find that instead of having, as before, an upward current occupying the whole of the chimney, we shall get an upward current on one side of the division, and a downward current on the other. This action obtains in mines. If the shafts are the same depth, and come to the surface at the same altitude, it is difficult to say which will have the upward current. That will generally depend on an accidental circumstance. It is easy to see the reason of the current when we consider that the bottom of the mine is warmer than the top, so that when a current is set up in one shaft, that shaft becomes occupied by a rarified column of air, whilst the other is filled with cold air of the normal density. The cold column being heavier than the warm column, a current is at once set up, the cold air entering the mine through one shaft, and the warm air leaving it through the other.

We have here a very simple apparatus to illustrate the phenomena.

Metalliferous mines seldom require artificial ventilation, but the case is different with collieries. The method employed in collieries, till within the last few years, was generally a furnace placed at the bottom of an upcast shaft. That system was very wasteful as far as the consumption of coal was concerned, and also had other serious practical objections. Collieries are now generally ventilated by means of fans put in communication with the up-cast shafts, and means are employed to utilise the shaft for other purposes, sometimes for pumping, and sometimes for both pumping and winding. It is easily seen that it is necessary, in order that the fan may perform its functions, that the top of the shaft should be closed. When the shaft is used for pumping purposes alone, that is easily done by covering the shaft and working the pump rods through holes in the covering. When used for winding, an ingenious arrangement of trap doors is provided, so that as the winding cage comes to the surface it pushes open the doors, and closes them again on its descent.

The general application of ventilating fans is indicated on one of the wall drawings. Its efficiency, compared with furnace ventilation, is very great. The general total efficiency of mechanical ventilation, by means of fans, is from 40 to 50 per cent. of the power applied, and the consumption of coal per horse-power of effective work done should not exceed 8 lbs. The consumption of coal for an equivalent work with the old furnace amounted to from 30 lbs. to 60 lbs.

As an example of mechanical ventilation, I may instance a Guibal fan, 46 ft. in diameter, and 14 ft. 10 in. wide, which extracts from the mine 246,000 cubic feet of air per minute.

In the Guibal fan the high velocity of the periphery of the blades is obtained with a slow rate of rotation by making it of large diameter, but smaller fans are made to give a large displacement by increased rapidity of rotation.

A Schele fan, 9 ft. 6 in. in diameter and 3 ft. 2 in. wide, gives a displacement of 106,000 cubic feet of air per minute.

This part of the subject probably possesses more human interest than any other, because good ventilation tends to prevent the accumulation of gas, the accidental explosion of which has so often shocked the public mind by suddenly sending so many of our brave miners to a premature grave. And here I would remark on the great attention which has been devoted to the subject of ventilation by colliery managers and others, and the perfection to which mechanical ventilation has been brought.

It is sad to know that, notwithstanding the science which has been brought to bear on the subject, gas does with subtlety sometimes collect in dangerous quantities. During the time of high barometric pressure it collects in waste places, and becomes suddenly liberated on the sudden fall of the barometer. Hence the reason for the colliery warnings which are frequently given in the papers when a sudden fall of the barometer is anticipated.

Mining has always been a more or less dangerous occupation; but we may safely say that great skill and labour have been successfully brought to bear on the subject, and that the danger is immensely lessened even when comparing it with what it was only a few years ago.

WINDING AND HAULING.

In the metalliferous mines the raising of the minerals is generally performed in a shaft or shafts specially devoted to that purpose. In collieries and other mines one shaft is often made to serve the combined purpose of winding, and pumping, and ventilating, by dividing it into sections with what is called brattice, or in other words, wooden partitions; but the general modern practice is to have two shafts, one forming the up-cast for the air, and the other the down-cast. Winding is frequently performed in both shafts.

The general principle of winding is now what it was in the year 1703, except that horse-power was then used and now steam.

A winding engine essentially consists of a drum, on which is coiled a rope. The two ends of the rope passing over pulleys supported on a head-gear over the shaft. To the ends of the rope are attached cages, in such a manner that when the drum is turned around, one cage ascends while the other descends.

When steam power was first introduced for winding, the engine ran at a higher speed than the drum, and was connected to it by gearing. The speed of winding was slow, and where the shafts were not very deep the problem presented no special difficulties. The competition which has sprung up in mining, as in all other things, forced upon mine owners the necessity of economy. In establishments such as mines the general charges are necessarily so great, that economy is best effected by increasing the output. The old geared engine was dispensed with (except in metalliferous mines, where the speed of winding is a matter of small consequence), and the direct-acting winding engine substituted. The speed of winding was thereby immensely increased, not without certain mechanical difficulties. The weight of coal raised at a time was increased, necessitating the use of heavy wire ropes. When the cage was at the bottom of the shaft, the length of the rope in the shaft added greatly to the weight on the engine, so that the engine in starting had not only to overcome the weight of the coal, but also the weight of the rope. As the cage ascended, the weight of the rope decreased, while the weight of the rope attached to the descending cage increased until the cages met in the middle of the shaft, when the two ropes balanced each other. One of the earliest contrivances to overcome this difficulty consisted of a counter-balance by means of heavy chains attached to the opposite side of the drum. When the cage was at the bottom of the pit the chains were in their highest position, but as the cage ascended the chains descended into a shallow pit, resting themselves at the bottom. As the cage approached the top of the pit the chains were lifted again by coiling in the opposite direction on the drum. A counter-balance running on wheels on an inclined plane was sometimes used to produce the same result. A modern system of counter-balancing is that recently introduced by a German engineer, Herr Kœpe, and consists of a tail rope hanging from the bottom of the cages in a loop, extending to the bottom of the shaft, and there passing over a pulley. This arrangement virtually forms the winding rope into an endless band, the loop of which extends over a pulley at the bottom of the shaft. There is always the same weight of rope in the shaft and the counter-balance is perfect. With this system Herr Kœpe considers that it is not necessary to coil the rope several times around the drum, but all that is necessary is to pass a loop of the rope over a sheave or pulley on the engine shaft, just like an ordinary driving belt. The friction between the rope and the pulley is sufficient to prevent slip, and to preserve the relative position of drum and cage. Winding is performed at very great speeds; it is therefore necessary that the engine-driver should have the reversing handle of the engine in his hand, with complete control over the engine movements. This condition of things renders expansive working not an easy matter, and it is only within the last few years that it has been successfully introduced. The early expansion gears were too complicated. The simplest gear is one which the author first saw in a colliery in Westphalia. German engineers have devoted considerable attention to this subject. The gear essentially consists of a sleeve, which is moved longitudinally on the gear shaft of the engine by means of the reversing lever. On the sleeve are shaped cam surfaces for giving motion to the valves. The expansion cam will be understood if you imagine the old stepped cam, formerly used in marine engines, with the steps so numerous that they form a continuous curve. The longitudinal motion of this sleeve is under the direct control of the engine-man, by means of the reversing lever.

As examples of modern winding I would give the following:—

A pair of 36-inch by 6-feet stroke winding engines wind from a depth of 1,300 feet about 1,100 tons in eight hours. Time occupied by the cage in coming up the 1,300 feet, 35 to 37 seconds. Total time occupied, including changing the trucks from double-decked cages, 58 to 60 seconds. In a pit 1,800 feet deep, 1,800 tons of coal have been raised, and 1,200 men and boys raised and lowered by one engine in one day.

In increasing the speed of winding, colliery engineers have not neglected considerations of safety, and winding cages are now provided with safety hooks; so that, should the engine-man accidentally overwind, the cage remains suspended in the headgear, instead of falling, as it would do without some such appliance, to the bottom of the shaft. Cages are also provided with safety appliances for causing them to be suspended in the guides, in the event of a rope breaking; but these are not very generally used. There is no reason why winding-ropes should break if properly inspected, and every care is now taken in that respect. Powerful steam brakes are applied to winding engines, so that, in case of accident, the engine-man can suddenly bring his engine to rest. In Germany it is the practice to employ mechanism attached to the engine, which shall cause the steam-brake to be automatically applied should overwinding occur.

If time would permit, I could go into other matters of detail in connexion with the subject, showing what a large amount of attention it has received from mining engineers.

To recapitulate, the chief difficulty in the way of steam economy in mines was that of using steam expansively—a difficulty arising from the varying nature of the work to be performed, and the necessity of simplicity of mechanism. Science has overcome that difficulty. Engines are now worked with considerable expansion in all departments of mining.

The output of mines has been greatly increased, and the standing charges reduced in consequence—considerations all the more important now that foreign competition is so keen. Germany, looking after her own interest, carries by her State railways coal to Hamburg from Westphalia at reduced rates, to enable Westphalia to compete with English markets.

The safety of the miner has been much raised by the applications of modern science; and whilst the mining engineer has economised the working of mines, he has, at the same time, rendered the occupation of the miner a safer, an easier, and a more profitable one.

DISCUSSION.

The CHAIRMAN said the paper contained a most interesting and wonderfully complete review of the machinery required in mining, omitting, of course, that used for dressing ores in connection with metalliferous mines. Among the many different machines which the author had described was a set of pumping machinery in a mine in France, where, owing to the shaft being already encumbered with the ordinary pumping and winding apparatus, it became practically impossible to introduce further pumping power into it, and the problem was, how the increased quantity of water could be raised. It appeared that in this mine there were periodical floodings, so that it was impossible to have a steam-engine at the bottom of the shaft, worked with steam from the surface, as was sometimes done; still less was it possible to have a steam-engine and boiler in that position, as in either case the engine might become submerged, and thus rendered incapable of working. Under these circumstances, the author had used the method of transmitting power from a distance, employed by Sir William Armstrong and others, *viz.*, water under pressure. This was an exceedingly useful and convenient mode of transmitting power, and possessed the advantage, that by increasing the pressure the size of the main and the mass of water in motion might be diminished. In this case the author employed pumps on the surface to send a continuous stream of water to work pumping-engines below, but in other cases similar work had been carried out by means of water-spears, or reciprocating rods of water, operated by plungers on the surface, working pumps below. Probably the continuous system was, on the whole, superior. He (the chairman) had had the advantage of seeing a French technical publication, in which there was a full description of these machines. The results given were quite as favourable as had been stated by Mr. Davey, and he believed they arose in great measure from the very ingenious method employed for the admission and discharge of the water. It might seem very remarkable that in one case mentioned, where steam was carried down a shaft 915 ft., although there was some loss by condensation, the pressure was 1 lb. greater at the bottom than at the surface, but it was easily explained. For instance, if there were a shaft 800 ft. deep, the pressure of the air at the bottom would exceed that at the top by an amount equal to a head of 1 ft. of water; but if there were in this shaft a tube containing air at double the density of the atmosphere, then the pressure of that air would at the bottom of the shaft be as much greater than the pressure at the top as would equal a head of 2 ft. of water; if now pressure gauges were put into the tube at the top and at the bottom, the bottom gauge would show an excess pressure over the top of 2 ft. head of water. He had been calculating the weight of the steam to which the author had referred; this appeared to be about double the density of the atmosphere, and if it were dry steam he did not think it would show much more than half a pound increase of pressure at the bottom; but the steam being surcharged with moisture from condensation would probably make up the difference and raise the pressure to the 1 lb. extra. The author, in alluding to the different modes of transmitting power for working underground machinery, had omitted to mention one which was devised by Mr. Hague, to whom both he and Mr. Crampton (whom he saw present) were apprentices some fifty years ago. At that early date he devised a very ingenious mode of transmitting power by exhaust air, which was used to a considerable extent in mines. At the time when the St. Katherine Docks were made, he had the offer of working all the cranes in this manner from a central engine, but not being quite as business-like as he was ingenious, he did not get the apparatus finished in time, though he (the Chairman) remembered very well the model which was made, just six months too late. Otherwise the whole of the cranage of those docks would have been worked, fifty years ago, from a central station, by exhaust air, much as Sir William Armstrong now did similar work by water pressure. The method, however, was extensively applied, among other instances, to the working of machinery in gunpowder factories, where it was then thought dangerous to use steam. It was also used for cranes, for hoists, for underground winding in collieries; and in connection with it there was also an ingenious method of lifting water, of which he would draw a rough sketch on the board. Assuming that coal was being worked to the "deep" and that it was desired to raise water up an incline then at about 20 feet from the bottom, an iron tank holding about 250 gallons, was placed, and a similar one at every 20 feet up to the surface. Running down past these tanks was an exhaust main, the vacuous condition of which was maintained by a pump at the surface; the tanks were also connected together by tubes, and the lower one, No. 1, with the water in the sump; so that the water was sucked from the sump into tank No. 1, then from that into No. 2, and so on into the top, where it ran out. Assuming the apparatus to be in regular work, the condition would be as follows:—Every alternate tank, say the odd numbers 1, 3, and so on were put in connection with the exhaust, and the even numbers 2, 4, &c., with the atmosphere. Then tank No. 1 sucked up water from the sump, and box No. 3, from box No. 2. In process of time Nos. 1 and 3, &c., became full, and 2 and 4 became empty; when they were empty the float fell and turned over by means of tumbling weights, three-way cocks, and made connection between 2 and 4, &c., the exhaust pipe, at the same time shutting off the air; while 1 and 3, which had become full by means of similar floats, reversed the cocks on them, making connection between them and the atmosphere, so that 2 and 4 now drew from 1 and 3; and so the process went on for any length of time. This was an extremely ingenious mode of raising water wholly irrespective of a vertical shaft, and required no moving parts or rods of any kind, and he thought it only right to mention these inventions of his old master, who also devised a plan for the purification of sugar by atmospheric pressure. Mr. Davey had referred to the tail rope of winding engines as a new invention, somewhat to his surprise, for he was under the impression that it was a very old one. A few weeks ago, in Wales, he saw a similar thing in the shaft of some slate quarries, where such a plan was essential because the shaft was worked by a water balance, consisting of two cisterns which over-balanced alternately when full, and brought up the skip; such an apparatus did not admit of much variation in the weight from top to the bottom. This was kept in perfect balance by means of a tail chain, and appeared to have been some years in use. The mode of allowing for the varying weight by means of winding a flat rope on itself, in the manner of a fusee, had been alluded to by the author; but an actual fusee had also been used with a round rope, the drum being made to taper at each end, the rope being kept in its place by grooves. A similar contrivance to that which the author had shown, as being used in Belgium, had also been employed with a round rope, made to coil on itself, a pair of flanges keeping the rope in its place. There was one other matter in connection with steel pit ropes to which he might also refer. As usually made, the outer strands ran in the direction of the axis of the rope, and the consequence was that when the rope had to bend, those strands had in some way to accommodate themselves to the difference between the interior and exterior circumference of a circle, a great strain was thrown upon them, and after a time they gave way and the rope was condemned. By a very simple change, which certainly did not improve the appearance to those accustomed to the ordinary form, this difficulty was got over. This was done by putting the parallel wires inside, and those which ran transversely being brought outside, the rope would then bend much more easily, because the straight wires were near the interior axis, and such ropes had been found to work for months without starting a strand. With regard to ventilating fans, he might mention that a week ago, being present at the opening of the Mersey Tunnel, he had the opportunity, in the company of Mr. Fox, the engineer, of inspecting the ventilating fans which were used there. There were two Guibal fans each of 40 ft. diameter, and one of 30 ft., so that ample provision seemed to have been made for keeping the tunnel ventilated. These fans were sometimes unpleasant neighbours, on account of the beating noise which they made, but by forming the outlet gradual this had been got rid of, and they now worked very quietly. The diagram of the Schiele fan on the wall did not represent the curved plates which were now used when the air was taken in at the two sides to prevent eddies, and which were very necessary to make the fan as efficient as possible.

Mr. BALDWIN LATHAM said the transmission of power was a matter which was applicable not only to mining, but to many other purposes. He was glad Mr. Davey had stated the probable duty which might be obtained in this way by means of air and also by water. In many towns air had been largely used in connection with drainage purposes, but it was clearly one of the most extravagant modes of transmitting power which could be used whilst the same thing could be done by water at much less cost. Mr. Davey was now putting up hydraulic machinery similar to that he had described, to move the sewage of a district which could not be dealt with locally, by transmitted power from a central station some miles distant. The sewage had to be lifted into a high level sewer, and the water was afterwards made use of for flushing purposes. The pressure in this case was about 400lbs. to the square inch. If this were compared with air at a pressure of 40lbs., the efficiency was about 4½ times greater. If the water were used at still higher pressure, the efficiency would be still greater, and the size of the mains, and, therefore, the cost, would also be reduced. Some day, perhaps, the electrical transmission of power would be made equally efficient; but of all the methods yet introduced air was undoubtedly the most extravagant, simply on account of the heat developed. Air could not be compressed to one-fourth its volume without a rise in temperature of 260°, which in its turn tended to expand the air three times, so that virtually there was a loss of 33 per cent. of power in the compression. With such a loss to begin with, added to that by leakage and friction, it was clear that for machinery on a large scale it was not in any way suitable.

Mr. THOMAS CRAMPTON thought the Chairman had hardly said enough in praise of their old master, Mr. Hague, who was a man very far in advance of his day. He used air, exhausted, not compressed, for driving the machines at the Mint, and for numerous other purposes, but somehow he was never up to time. It was a great pity that all he did was not properly recorded. With regard to the subject of the paper, he thought Mr. Davey had thoroughly exhausted it. He felt much interested in the transmission of power by means of water, and had a notion that if ever the Channel Tunnel were allowed to be made, it would have to be done in that way; as to doing it by compressed air, as was proposed, it was quite ridiculous, and he could never understand how air could be used with so little loss as was stated.

Mr. HARPER said he read a paper some ten years ago on a method of counterbalancing winding engines by means of compressed air; an engine was used to compress the air into a receiver during the lowering, and when the load started at the bottom, the air would be used to aid in the ascent. He did not know whether or not it had been practically applied.

Mr. J. H. COLLINS asked what was the consumption of coal in the large engines which raised four million gallons of water 600 feet?

Mr. W. B. BRYAN said he was much interested in the remarks made as to the efficiency of the Cornish engine and plunger pump as compared with the old engines using bucket beams. It reminded him of a paper by Mr. Palmer, at the Institution of Civil Engineers about forty years ago, in which he fell foul of Mr. Wicksteed, the engineer to the East London Water Works, and also of a great many engineers in Cornwall as regarded the efficiency of Cornish engines, and said that to speak of 90, 100, or 110 millions of foot-pounds raised with a bushel of coal was all nonsense. He proved conclusively to himself that no engine could ever raise more than forty millions, because he said if you took a cubic foot of water and turned it into steam, you had 1,642 cubic feet, and if the whole of that were condensed, supposing the vacuum to be absolutely perfect, it would lift the water 34 ft. high, which, worked out, came to about the forty million foot-pounds. However, he (Mr. Bryan) understood that Mr. Davey had obtained an efficiency of over eighty millions from these engines. With regard to the transmission of power underground by hydraulic pressure, he made out from the figures that 30 lbs. of steam were used to produce 1 horse-power in lifting water, which was a splendid result. Supposing you could produce 8 lbs. of steam with 1 lb. of coal, that came to 3¾ lbs. per horse-power of work effected, which, considering the friction of the two engines, was something marvellous, especially as compared with the miserable economy of compressed air. Some years ago he designed some hydraulic engines for lifting a million gallons of sewage 24 ft. high, the pressure being 125 lbs., and the efficiency was exceedingly good, though not equal to that of the engines which had now been described, but they had been working very satisfactorily up to the present time, perfectly automatically, being looked at only once a day and oiled. They were left entirely to themselves, they started and stopped themselves, and they were in position where an engine and boiler would have been quite out of the question. He found Mr. Davey's figures as to compressed air agreed very closely with those given him by Colonel Beaumont, the inventor of a machine for tunnelling by this means. There might be one advantage in using it for this purpose, and that was in the ventilation. The Mont Cenis Tunnel was driven in great measure by air-compressing machinery, and though the efficiency was very small, perhaps 25 to 28 per cent., the ventilation of the heading helped to counterbalance it.

The CHAIRMAN remarked that it was explained in the paper that the compressed air machines which were described had been worked without expansion, and also without any means of heating the air. There was a system of compressed air tram-car which had been at work for the last five years in Nantes, where the air was carried in bottles under a pressure of 450 lbs. per inch, and when the car took in the charge of air it also took in a charge of hot water from the boiler, which was under a pressure of steam of about 70 lbs. The air on its way to the cylinders was caused to pass through this hot water, so that it was warmed, and was capable of being used expansively in the engines without the risk of producing ice, and was also in a good lubricating condition. A similar car was worked at the Inventions Exhibition, the only difference being that the air there was used in two compound cylinders instead of one, and that it also passed through two "hot-pots," as they were termed, on its way to the cylinders.

Mr. DAVEY, in reply, said he knew the method of reciprocating water columns, for the purpose of giving motion to underground engines, had been used; it was tried in some mines at Saarbrucken some ten or twelve years ago, but was not a success, for two or three practical reasons. It was found extremely difficult to keep the engines working in unison with each other, and the water-spears lengthened and shortened themselves by leakages. The first device for overcoming this difficulty was to put a bell at each end of the water-pressure engine, and make the cross-head strike it whenever it exceeded its normal stroke, so calling the attention of the engine-man, who at once opened a communication from one main to the other, and adjusted the length of the water-spears. This, of course, was a tedious process, and involved keeping a man constantly by the side of the hydraulic engines. Then an automatic apparatus was introduced, but he was informed that the use of the engines had been discontinued. When he commenced the application of water-pressure to underground engines, he considered the advisability of using some such system, but could never persuade himself that he could make it perfectly successful, and therefore adopted the continuous method. Another reason was that the company intended working rotary machinery from the same source. During the trials, the engines at the surface made twenty-two revolutions per minute, and those underground five double strokes; but those on the surface were capable of working up to thirty or thirty-five revolutions with perfect safety, probably more, so that there was a large reserve power. The pipes, which were 7 in. in diameter, were capable of conveying 250 horse-power, with no appreciable loss by friction, but at present only 229 horse-power was used. It was the intention to work the hauling engines from the same source, and in almost all similar installations this would be done. Anyone putting down such a system in a colliery would never dream of putting down separate engines to work the hauling engines and the pumps. He knew the tapering drum, and had seen some splendid examples both in England and on the Continent, where it was more often used, but he believed the tail rope was becoming a greater favourite. It was very old, no doubt, because it would be difficult to conceive its not suggesting itself to every mining engineer. When he spoke of it as a new invention, he referred rather to its simply passing over a sheave on the winding engine instead of round the usual drum. The rope was not so much affected by that arrangement, and it was this, in combination with the loop running in a pulley under the cage, which he understood Herr Kœpe claimed as his invention. With regard to the fan, it was quite true the drawing, which was a borrowed one, did not show the conical surfaces referred to by the Chairman, and which were necessary where there was a double inlet. The beating noise referred to resolved itself, in a high-speed fan, into a hum, but by a little experimenting and alteration he had been able to overcome this entirely in a ventilating fan he had to put up at the Yorkshire College, where it was necessary that it should work silently. This was accomplished without the least decrease in efficiency. In reply to Mr. Collins, he could not give the exact quantity of coal consumed, but he knew similar engines gave about 60,000,000 duty, which was equivalent to 3 lbs. of Welsh coal per horse-power. To raise the quantity of water named, the engines would exert about 500 horse-power, which would give 25 lbs. per minute, or 1,500 lbs. per hour. He quite agreed with what Mr. Bryan had said as to Cornish engines, and also as to hydraulic transmission of power.

The CHAIRMAN then proposed a vote of thanks to Mr. Davey, which was carried unanimously.

Miscellaneous.

BEVERAGES OF BARBARY.

Besides wine from the grape, whose preparation calls for no special notice, there is a kind of "palm wine" or *lakmi*, furnished by the sap of the date palm (*Phœnix dactylifera*). Trees in full vigour are selected for tapping. If the life of the tree is to be sacrificed, the incision is made so as to destroy the terminal bunch; but more generally the tree is to be preserved, and in that case the cut is kept clear of the terminal bunch, and is carried round the stem. The juice escaping from the wound is conducted by a reed into an earthenware pot (*karreri*), and may amount to nearly two gallons daily at first, gradually sinking to about half that quantity towards the end of the tapping, which is seldom allowed to exceed a month. The collection being terminated, the incision is carefully plastered up with clay, and after about two years, with irrigation, the tree will resume fruit bearing. Much of the "wine" is drunk fresh, when it resembles sparkling cider, but becomes insipid after losing its carbonic acid. Its colour is opalescent and milky. After undergoing alcoholic fermentation, it contains 4·38 per cent of alcohol, 0·22 carbonic acid, and 5·60 of mannite.

The Moors make extensive use of a spirit prepared from the water in which comb is boiled in treating beeswax. This water, being impregnated with honey, is allowed to ferment, and is then distilled; the spirit is called *maharga*. It is flavoured with aniseed or with *naffa*, *i.e.*, fennel acid (*Fœniculum dulce*).

AGRICULTURE IN RUSSIA.

The total area of Russia in Europe, excluding Finland, is about 1,180,000,000 acres, which are distributed as follows:—Arable land, 257,000,000 acres; meadow land, 143,000,000 acres; forest land, 472,000,000 acres; and waste land, 308,000,000 acres; so that about a quarter is waste, a quarter arable, three-eighths forest, and one-eighth meadow land. Consul-General Stanton, of St. Petersburg, says in his last report that of the various crops planted, grain occupies the largest area, and from climatic causes, the cultivation of spring wheat prevails, winter wheat being grown to a greater extent than spring wheat only in Poland, the Baltic, and the western and south-western provinces. The area planted in European Russia being—winter wheat, 7,913,000 acres, and spring wheat, 23,027,000 acres. The Baltic provinces and Poland yield the most, viz., fivefold the amount sown. Rye is the chief cereal of Russia, both as regards the amount cultivated and exported; it is also extensively used for distilling purposes. It is almost the only winter cereal grown between the 52° and 63° north latitude, or in about half of European Russia. The average yield is fourfold the amount sown, the largest crops being found in the Baltic provinces. Oats, excepting in the far north, are grown throughout the empire, and the average yield is about 478,000,000 bushels, or more than threefold the amount sown. Barley is cultivated in the highest latitudes, where it forms the chief cereal, in the western governments, for brewing purposes, and in the south as a substitute for oats. It is most extensively grown in Poltava, Cherson, Kiefa, Kovno, Viatka, and Podolia, and its export increases annually. Buckwheat, the north excepted, is cultivated throughout Russia, and in Russian governments to a greater extent than barley. The consumption is very great, buckwheat groats being for the peasants and lower classes an almost daily article of food. Considerable quantities are exported to Germany and Holland. It is the chief food for bees, and its cultivation is always accompanied by bee-keeping. Maize is only cultivated to any considerable extent in the Caucasus, Bessarabia, parts of Taurida, Cherson, Podolia, and Yekaterinoslaff, the grain being mainly used as fodder. Peas, beans, lentils, and millet, are grown in almost all parts, particularly in Great Russia. The sunflower is most extensively grown in Voronesh and Saratoff. Potatoes are largely cultivated in Russia, both as food and for distilling purposes, and the failure of the crops in 1839 and 1849 led the Government to encourage its cultivation by bounties. Except in cities, the lower classes prefer groats and sauerkraut to potatoes. The lack of manure and labour restricts the cultivation of the potato, which is generally planted in fields where rye has been grown during the winter. In 1878, 76,052,000 bushels were planted in European Russia, and 390,260,000 reaped. Russia takes the first rank in the cultivation of flax, which is very extensively exported. From 600,000,000 to 700,000,000 pounds of flax are annually produced, and about 22,000,000 bushels of linseed harvested. Nearly 2,700,000 acres are cultivated, and the culture is almost exclusively in the hands of the peasants. The cultivation of one dessialine of land, the dessialine being equivalent to about 2·7 acres, demands one hundred and three days, twenty-six of which are devoted to the plant and seventy-seven to the preparation of the fibre, and estimating the labour and rent to be about £17, and the gross receipts exclusive of seed at about £24, the profit is only about £7 per dessialine cultivated. About 14,250,000 bushels, valued at between four and five millions sterling, are annually exported. Although Russia ranks first in the amount of flax produced, Austria, Germany, Holland, France, England, Belgium, and Ireland, far surpass it in the amount produced on a given area. Hemp ranks next to flax, and is also largely exported. It is cultivated chiefly in the central governments, the annual production being about 216,000,000 pounds weight, and about 14,000,000 bushels of hemp seed. It is also mainly cultivated by the peasants. It is said that the introduction of chain and wire tackle for ships, the decrease in the number of sailing vessels, the increasing use of cotton, jute, and petroleum, have seriously affected the Russian flax and hemp trade. Beet-roots were first cultivated at the beginning of the present century, and the industry has been largely developed since 1840. They are cultivated in twenty-three governments, nine of which belong to Poland. The area cultivated in 1883 amounted to 734,000 acres, and the annual yield to 5,400,000,000 pounds. Kief is the centre of production. The roots are grown by large estate owners and peasants, and always in the vicinity of factories. Those of the south-west contain the greatest amount of saccharine matter, about 16 per cent., those of Poland 11 per cent. to 13 per cent., while in some districts the proportion is as low as 7 per cent. As regards the production of tobacco, Russia ranks second among continental countries, but the consumption is less per head than in other lands. Consul Stanton says that smoking began in the latter part of the 16th century, and the habit steadily increased, notwithstanding the fact that it was punished by the knout, slitting of the nostrils, and banishment to Siberia. It is most extensively cultivated in Tshernigoff, Poltava, Bessarabia, and Samara. In Poland, the production is not large, and is mainly confined to the vicinity of Warsaw. It is chiefly cultivated by the peasants and is often their only occupation. The vine-growing district of Russia covers an area twice as large as that of France, and produces only 40,000,000 gallons of wine annually (about 6 per cent. of the total wine production of France), 13,000,000 gallons of which are consumed in the district. The vineyards of Transcaucasia yield the greatest net profit, about £95 per dessialine, and of Yarta £84 per dessia-line. About 0·2 per cent. of the wine sold is exported. Horse-breeding is a branch of agricultural industry largely cultivated in Russia, and dates back for many centuries. There are more domestic animals in the Russian Empire than in any other country in Europe, and with regard to cattle, the country may be divided into three zones—the northern, southern, and south-eastern. In the first, cattle are kept chiefly for dairy purposes and manure. The breeds kept are native, often crossed with foreign breeds, and are small in stature. In the second zone, cattle are kept as beasts of burden. They are largely exported. In the south-eastern zone Oriental breeds are kept chiefly for their meat and tallow.

Correspondence.

MECHANICAL MOTORS FOR TRAMWAYS.

Mr. BERNARD DRAKE writes regarding the report of his remarks in the discussion on Capt. Galton's paper (see *ante* p. 171 :—"The efficiency of the cells used in the tram-car experiments at the works of the Electrical Power Storage Co. is stated to be 75 per cent. in ampères, this should read 85 per cent. in ampère-hours. In the next sentence the statement made by the writer was 'that we had endeavoured to reduce the number of sets of cells necessary for each car in regular work to a minimum, viz., three, and therefore re-charged the cells at as rapid a rate as possible.' With referance to Julien's cells for 'production' of local action, read 'prevention.'

"Also, it was stated that in practice it was found possible, by suitable treatment, to practically eliminate the local action between pure lead and peroxide, though theoretically it should be considerable.

"For 'locomotor force' read 'clecro-motive force.'"

General Notes.

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Trams at the Antwerp Exhibition.—The *Times* Brussels Correspondent sends the following note on the awards to the mechanical motors for tramways, described by Captain Galton in his paper read before the Society on the 20th inst. (see *ante*, p. 157):—"The jury deputed to award the prizes in the competition of self-acting tramway cars for street use, on the occasion of the Antwerp Exhibition, has conferred on the Electric Company at Brussels the diploma of honour; on Messrs. Black, Hawthorn, and Co. (Wilkinson system), of Newcastle-on-Tyne; W. Rowan, of Berlin, and Krauss and Co., of Munich, silver medals; and on the Beaumont Compressed Air Locomotive Company a bronze medal. Visitors to the Exhibition will recollect that the cars of the different systems ran along the Boulevard des Arts, the principal artery of communication between the terminus and the Exhibition."

Bone Industry in California.—The bone industry is carried on, on a large scale, in California. A large quantity of leg bones are exported to Europe for making knife-handles and for other purposes, and sell for about 40 dollars per ton. The feet of cattle are used for making oil, the four feet of an ox, yielding about a pint. The rib bones which are most in demand fetch as much as 80 dollars per ton, these are used for making tooth and other brush handles. The bones of the fore legs, which are used for button making, umbrella handles, &c., are worth about 30 dollars a ton, whilst other bones and waste pieces are ground for manure or made into animal charcoal, largely used for sugar refining. Even the water in which bones have been boiled is utilised for glue making, and everything is turned to account.

MEETINGS OF THE SOCIETY.

ORDINARY MEETINGS.

Wednesday evenings, at Eight o'clock:—

THE FOLLOWING DATES HAVE BEEN FIXED.

FEBRUARY 3.—"Artistic Bronze Casting." By GEORGE SIMONDS.

FEBRUARY 10.—"Mining Industry at the Buda-Pest Exhibition." By BENNETT H. BROUGH.

FEBRUARY 17.—"Some Points in Electrical Distribution." By Professor GEORGE FORBES.

FEBRUARY 24.—"The employment of Autographic Records in Testing Materials." By Prof. W. C. UNWIN.

MARCH 3.—"Calculating Machines." By C. V. BOYS.

MARCH 10.—"The Experiments with Lighthouse Illuminants at the South Foreland." By PRICE EDWARDS. Lord RAYLEIGH, Secretary of the Royal Society, will preside.

DATES TO BE HEREAFTER ANNOUNCED:—

"The Treatment of Sewage." By Dr. C. MEYMOTT TIDY.

"Domestic Electric Lighting." By W. H. PREECE, F.R.S.

FOREIGN AND COLONIAL SECTION.

Tuesday evenings, at Eight o'clock:—

FEBRUARY 16.—

MARCH 23.—"The Commercial Progress of New South Wales." By EDWARD COMBES, C.M.G.

March 2; April 13; May 18.

APPLIED CHEMISTRY AND PHYSICS SECTION.

Thursday evenings, at Eight o'clock:—

FEBRUARY 11.—

FEBRUARY 25.—"Photography and the Spectroscope in their Application to Chemical Analysis." By Professor W. N. HARTLEY, F.R.S.

MARCH 11.—

APRIL 8.—

MAY 13.—"The Scientific Development of the Coal Tar Colour Industry." By Professor R. MELDOLA, F.C.S.

INDIAN SECTION.

Friday evenings, at Eight o'clock:—

FEBRUARY 19.—"Historical and Recent Famines in India." By F. C. DANVERS, F.S.S., Registrar and Superintendent of Records, India-office. J. M. MACLEAN, M.P., will preside.

MARCH 19.—"Experiences on the Afghan Frontier." By WILLIAM SIMPSON. Col. HENRY YULE, C.B., will preside.

April 2; May 7, 21.

The above dates are liable to alteration.

CANTOR LECTURES.

The Second Course will be on "Friction." By Prof. H. S. HELE SHAW.

Lecture III.—February 1.—The Mechanical Applications of Friction.

Lecture IV.—February 8.—The Methods of Reducing Friction.

ADDITIONAL LECTURES.

"Japanese Art Work." BY ERNEST HART.

Lecture I.—May 4.—Japanese Metal Work.

Lecture II.—May 11.—Japanese Porcelain and Pottery.

Lecture III.—May 18.—Japanese Picture Books and Drawings.

MEETINGS FOR THE ENSUING WEEK.

MONDAY, FEB. 1...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. (Cantor Lectures.) Prof. H. S. Hele Shaw, "Friction." (Lecture III.)

Farmers' Club, Inns of Court Hotel, Holborn, W.C., 6 p.m. Mr. H. M. Jenkins, "Co-operation between the Producers and Consumers of Meat."

Engineers, Westminster Town-hall, S.W., 7½ p.m. Presentation of Premiums by Mr. Charles Gandon. Inaugural Address by the President for 1886, Mr. Perry Fairfax.

Chemical Industry (London Section), Burlington-house, W., 8 p m. 1. Mr. Gustav Bischof, "Notes on Dr. Koch's Water Test." 2. Mr. Westmoreland, "The Estimation and Valuation of Copper Ores and Products for Commercial Purposes."

British Architects, 9, Conduit-street, W., 8 p.m.

Medical, 11, Chandos-street, W., 8½ p.m.

Victoria Institute, 7, Adelphi-terrace, W.C., 8 p.m. Professor G. E. Post, "The Flora of the East."

London Institution, Finsbury-circus, E.C., 5 p.m. Prof. E. Ray Lankester, "Charles Darwin and his Theory." (Lecture I.)

TUESDAY, FEB. 2...Royal Institution, Albemarle-street, W., 3 p.m. Dr. R. Stuart Poole, "The Egyptian Sources of Greek Art." (Lecture III.)

Central Chamber of Agriculture (at the HOUSE OF THE SOCIETY OF ARTS), 11 a.m.

Civil Engineers, 25, Great George-street, S.W., 8 p.m. Adjourned discussion on Mr. C. E. Stromeyer's paper, "The Injurious Effect of a Blue Heat on Steel and Iron."

Pathological, 53, Berners-street, Oxford-street, W., 8½ p.m.

Biblical Archæology, 9, Conduit-street, W., 8 p.m.

Zoological, 11, Hanover-square, W., 8½ p.m. 1. Dr. G. Stewardson Prady, "Notes on Freshwater Entomostraca from South Australia." 2. Dr. Monticelli, "Contributions to a Knowledge of the South Italian Cheiroptera." 3. Mr. R. B. Sharpe, "Notes on Birds in the Hume Collection." (No. I.) "The Hawfinch from Attock."

WEDNESDAY, FEB. 3...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. Mr. George Simonds, "Artistic Bronze Casting."

Entomological, 11, Chandos-street, W., 7 p.m.

Archæological Association, 32, Sackville-street, W., 8 p.m. 1. Rev. C. Collier, "Report on the Excavations now in progress at Winchester Cathedral." 2. Paper by Mr. H. Syer Cuming.

Obstetrical, 53, Berners-street, 8 p.m. Annual Meeting.

THURSDAY, FEB. 4...Royal, Burlington-house, W., 4½ p.m.

Antiquaries, Burlington-house, W., 8½ p m.

Linnean, Burlington-house, W., 8 p.m. 1. Mr. Francis Darwin, "Relation between the Bloom of Leaves, and Distribution of Stomata." 2. Mr. E. C. Bousfield, "Slavina and Ophidonais." 3. Dr. E. Benavia, "Probable Source of Cultivated True Limes." 4. Prof. R. J. Anderson, "Relative Length, Segments of Chicks' Limbs during Development."

Chemical, Burlington-house, W. 8 p.m. Dr. Klein, "Methods of Bacteriological Research from a Biologist's Point of View."

London Institution, Finsbury-circus, E.C., 7 p.m. Dr. E. Freeman, "The Nature of Historical Evidence."

Society for the Encouragement of Fine Arts, 9, Conduit-street, W., 8 p.m. Professor Kerr, "The Art-Scepticism of the Day."

Parkes' Museum of Hygiene, 74A, Margaret-street, W., 8 p.m. Dr. G. A. Heron, "How it is shown that Living Things cause some of the Diseases of Man."

South London Photographic (at the HOUSE OF THE SOCIETY OF ARTS), 8 p.m.

Royal Institution, Albemarle-street, W., 3 p.m. Prof. W. Chandler Roberts Austen, "Metals as affected by Small Quantities of Impurities." (Lecture II.)

Mechanical Engineers, 25, Great George-street Westminster, S.W., 7½ p.m. Annual General Meeting. 1. Mr. J. Hartley Wicksteed, "Description of an Autograph Test-Recording Apparatus." 2. Description of Tensile Tests of Iron and Steel Bars," by the late Mr. Peter D. Bennett. 3. Mr. Alfred A. Langley, "Description of a Hydraulic Buffer-Stop for Railways." 4. Mr. J. Alfred Griffiths, "The Distribution of the Wheel Load in Cycles."

Archæological Institution, 16, New Burlington-street, W., 4 p.m.

FRIDAY, FEB. 5...Mechanical Engineers, 25, Great George-street, S.W., 7½ p m. Annual Meeting. Reading of paper and discussion continued.

United Service Institute, Whitehall-yard, S.W., 3 p.m. Mr. Morsten Nordenfelt, "Nordenfelt's Submarine Boat."

Royal Institution, Albemarle-street, W., 8 p.m. Weekly Meeting. 9 p.m. Mr. T. Pridgin Teale, "The Principles of Domestic Fire-place Construction."

Geologists' Association, University College, W.C., 8 p m. Mr. W. Topley, "The Life and Works of Prof. John Morris."

Philological, University College, W.C., 8 p.m. Dr. Whitley Stokes, "Notes on Curtius's Greek Etymology."

SATURDAY, FEB. 6 ... Royal Institution, Albemarle-street, W., 3 p.m. Prof. A. Geikie, "The History of Volcanic Action in the British Isles." (Lecture II.)

CORRECTION.—Page 170, col. 1, line 12, *for* 3s. 3d., *read* 3.3d.; line 15, *for* 4s. 8d., *read* 4.8d.

Journal of the Society of Arts.

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FRIDAY, FEBRUARY 5, 1886.

All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

NOTICES.

CANTOR LECTURES.

The third lecture of the course on "Friction" was delivered on Monday evening, the 1st inst., by Prof. Hele Shaw, who treated specially of the mechanical applications of friction.

The lectures will be printed in the *Journal* during the summer recess.

Proceedings of the Society.

APPLIED CHEMISTRY & PHYSICS SECTION.

Thursday, January 28, 1886; Thomas Gray, C.B., in the chair.

The paper read was—

MAGNETISM OF SHIPS AND THE MARINER'S COMPASS.

By William Bottomley.

Twenty years ago the writer of an article on the "Mariner's Compass" remarked:—

> "There are some subjects which seem to be doomed to general neglect, almost on account of their peculiar claims to universal attention. A seafaring people might be supposed, as a matter of couse, to take a deeper interest in the theory of the Mariner's Compass than in almost any other branch of science, and yet it is scarcely too much to say that the investigations which have revolutionised this department of magnetical science have awakened no interest in the general public, and have scarcely been mastered by more than a few of those whose lives are hourly risked upon the supposed accuracy of the compass indications."

The same remark might with almost equal truth be made at the present day. Perhaps one of the principal reasons why so little interest is taken in this subject, and why the effect of the magnetism of the iron of a ship on the mariner's compass is so little understood by the majority of sailors, is because the books and papers which have been written on the subject are put in too mathematical a form to be intelligible to ordinary readers.

I have been asked by the Council of this Society to give you this evening an account of the magnetism of an iron ship, and the means which are adopted for counteracting its effect on the Mariner's Compass.

The subject of the magnetism of a ship is one of considerable complexity, and to understand it completely requires a certain amount of mathematical knowledge. It would be impossible, in the course of a single paper, to give any detailed explanation of the theory of an iron ship's magnetism. I shall, therefore, confine myself to giving a general idea of those magnetic forces which are found to exist in an iron ship, and which combine to produce the errors of the compass so troublesome and dangerous to the navigator.

Before entering on the subject, it may be desirable to give some brief explanation of those fundamental principles of magnetism which are intimately connected with the Mariner's Compass.

Magnetism may be defined as the power which certain bodies called magnets possess of attracting iron. There are two kinds of magnets—natural and artificial. Natural magnets are found as an ore of iron called loadstone; artificial magnets are made of bars of tempered steel, and are magnetised by the action of other magnets, or by a current of electricity. If a straight bar magnet be examined, it will be found that the magnetism in it is not uniformly distributed along the length of the magnet, but that the attractive force is most powerful near each end and diminishes towards the centre.

If a magnet be hung by a fine thread round the middle of the bar, or suspended on a point, so as to be free to turn round a vertical axis, it will be found to take up a fixed direction—one end of the magnet will point towards the north and the other end towards the south. Now, if another magnet be brought near this suspended magnet, it will be found that the pole of the latter pointing towards the north will be attracted by one end of the second magnet, and repelled by the other end. Similarly the end of the suspended magnet pointing towards the south will be attracted by one end of the second magnet, and repelled by the other. But the pole of the second magnet which attracts the north-pointing end of the suspended magnet will repel the south-pointing end, and the pole which repels the north-pointing end will attract the south-pointing end.

Now, if I suspend this second magnet similarly to the first, you will see that the end which attracted the north-pointing end will turn towards the south, and the end which attracted the south-pointing end will turn towards the north. We thus learn that there is a difference in the magnetism of the two ends of a magnet, and, further, that similar poles repel one another, and opposite poles attract one another.

The fact—which constitutes the essence of the Mariner's Compass—that a suspended magnetic needle takes up a definite position has been known for a very long time. It is said to have been used by the Chinese as a guide for travelling by land somewhere about 2400 B.C. Whatever may be the exact time of its becoming known in China, it seems to be certain that it was a long time after that—probably several thousand years—before it became known in Europe. Indeed, the introduction of the Mariner's Compass into Europe has not been traced to an earlier date than the end of the eleventh century.

The true explanation of this wonderful phenomenon, of the tendency of a suspended magnet to turn to a definite direction, was first given in the year 1600, by Dr. Gilbert, physician-in-ordinary to Queen Elizabeth, in his famous work on "The Magnet, and the Earth a Great Magnet." He explained that the earth acts on a moveable magnet in the same way that another magnet does; in fact, that the earth may be considered as a large magnet having one of its poles situated somewhere near the North Pole of the earth, and the other near the South Pole of the earth. One end of a moveable magnet points towards the north because it is attracted by one of the magnetic poles of the earth, and the other end points towards the south because it is attracted by the other magnetic pole of the earth.

Now I have shown you already that similar poles repel, and dissimilar poles attract. Therefore the magnetism of the pole of this magnet which is attracted by the north magnetic pole of the earth must be dissimilar to the magnetism of the northern portions of the earth, and similar to the magnetism of the southern regions. The end of the needle which is repelled from the north, and attracted to the south, must have magnetism similar to the earth's northern regions. Thus the end of the needle which points *from* the north has true northern polarity, and the end which points *towards* the north has true southern polarity. Gilbert pointed this out, and protested against the practice of writers, instrument makers, and sailors speaking of the end of a magnet which is attracted towards the north as the North Pole of the magnet. Unfortunately, this mistake has been persisted in to the present day. We still find instrument makers marking with an N the end of the magnet which is attracted by the North Pole of the earth, and many writers of books, and even some scientific papers on magnetism, speak of this end of the magnet as the north pole of the magnet. From this they are driven to call the magnetic pole of the earth situated in the northern hemisphere the earth's south magnetic pole.

The following appears in a popular account of the Mariner's Compass. Speaking of an iron bar held in a vertical position in the northern hemisphere, it says "its lower end is nearer the earth's south pole;" then a note is added, "that is the pole similar to the south pole, and capable of attracting the north pole of an ordinary magnet. This is always spoken of as the earth's south pole, although north in geographical position."

In order to avoid the confusion which is thus caused, it has been proposed by Sir George Airy to colour the poles of magnets blue and red. The blue end being the one which has magnetism similar to the northern regions of the earth, and the red end magnetism similar to the southern regions of the earth. The adoption of this proposal generally would do much to avoid the confusion and difficulty which is felt by practical men in understanding the principles of magnetism in connection with the mariner's compass.

It is quite proper to mark the point of the compass card which points to the north with an N, and the point which points to the south with an S, and these points may without any confusion be called the north and south points of the card; but when the end of a magnet which is attracted towards the earth's northern magnetic pole is spoken of as having northern polarity, or is marked with the letter N., this gives a wrong idea, and produces confusion in the mind of the learner. The confusion is annulled when Sir George Airy's excellent proposal is adopted.

The magnetic poles of the earth do not coincide with the astronomical poles. In the northern hemisphere the magnetic pole is situated to the N.N.W. of Hudson's Bay. The southern magnetic pole has not been reached by anyone, but it was so nearly approached by Sir James Ross that there can be no doubt of there being a southern magnetic pole at a point to the south of Tasmania.

Now, a magnetic needle when influenced only by the earth's magnetic attraction points to the magnetic pole and not to the true or astronomical pole.

Thus the north and south as shown by compass do not usually agree with the astronomical north and south. The angle which the compass needle is deflected from the astronomical north when influenced by the earth's magnetic force is called the variation of the compass. The variation differs in different parts of the earth. Charts showing the variation of the compass in different parts of the world have been published by the Admiralty. The variation at any particular place does not remain the same always. Ever since accurate observations of terrestrial magnetism were made, the distribution of it over the earth has been constantly changing. As an example of the changes which have taken place in the direction of the earth's magnetism, I may tell you what has occurred in London since the middle of the 16th century.

The variation in 1580 was 11° 15′ to the east of the true north. The easterly variation gradually diminished till 1659, when the needle pointed to the true north; after that it began to point to the west of north, and the westerly variation continued to increase until the year 1820, when the needle pointed 24½ degrees to the west of true north. From that time until now the westerly error has been diminishing. At the present time the variation at Greenwich is 17° 54′ westerly, and it is decreasing about six minutes annually. It is important, when taking the variation from a chart, to correct it up to date. If the chart is five years old, an error in the variation of nearly one degree may be made in some places.

The compass used on board all ships at the present time is substantially the same as that described by Gilbert three hundred years ago. It consists of the compass card, the bowl with gimbal ring, and the box or binnacle for supporting the bowl. The ordinary compass card now used is made of a thin disc of mica or cardboard, to the lower side of which are attached magnetic needles made of parallel straight bars of flat steel, with the breadth of the bar perpendicular to the card. In the Admiralty standard compass there are two pairs of needles; in the compasses of merchant ships there is generally only one pair of needles attached to the card; in Sir William Thomson's compass there are four pairs of very small round steel needles hung from the rim of the card by means of silk threads. The circumference of the card is divided into degrees, and inside the circle of degrees the card is further divided into points and quarter points. In the centre of the card there is a jewelled cap, which bears the whole weight of the card and needles on a fine point of hardened steel, or of a natural alloy of iridium and osmium, which is much harder than steel, and is not liable to rust. The compass bowl is a circular box formerly made of wood, but now made of brass or copper with a glass cover on the top. The bowl, with a weight attached to its bottom, is supported on a brass ring at opposite points by pivots projecting from it, so as to allow the box to swing inside the ring. The ring is similarly supported on the binnacle by pivots projecting from it, the line of these pivots being at right angles to the line of the pivots on the bowl. When thus supported, the compass bowl, which is said to be supported on gimbals, can always take up a horizontal position.

The bearings of the bowl and gimbal ring are usually round journals. In order to give greater freedom to the bowl to assume a horizontal position, Sir William Thomson uses knife edges instead of round journals, and to calm the vibrations of the bowl, he attaches a hemispherical shell to the bottom of the compass box. This shell is nearly filled with a viscous oil. The flowing of the oil on the bottom of the shell prevents the bowl getting into a swing. To prevent the vibrations from the engines of a steamer affecting the compass card, it is found necessary to hang the bowl and gimbal ring by an elastic suspension from the binnacle. This is usually done with india-rubber bands; but Sir William Thomson has adopted a novel elastic suspension which has proved remarkably successful—particularly so on board ships of war during the fire of heavy guns. He uses an elastic ring of brass wire, made up similarly to a rope grummet ring, which is well known on board ship. From this elastic ring the gimbal ring is hung by brass chains.

The Admiralty standard compass is only 7½ inches in diameter, and the steering compasses used in the British navy are now usually 10 inches in diameter. In the merchant service the larger card is preferred, and it is almost always 10 inches or more in diameter. In some of the large ocean steamers compass cards of 15 inches diameter have been used, but a card of this size is only suitable for steering compasses, where it is important to have the space between each degree as large as possible, so that the steersman may notice at once when the ship goes off her proper course. For standard compasses, a card of 10 inches diameter appears to be the most suitable. A 10 or 12 inch compass card is much steadier in a heavy sea than a similar card of 6 or 7 inches in diameter, and it is this advantage which has led to the 10 inch card being generally adopted in the British merchant service.

Until a few years ago it was usual to make compass cards with long and powerful magnets, as it was considered that the greater the "magnetic moment" of the needles the better the compasses. In 1874 Sir William Thomson pointed out that the greater the magnetic moment, all other circumstances being the same, the more unsteady will the compass be when the ship is rolling. With the heavy compass cards universally used at that time, the magnetic needles required to be made large and strong, in order to have sufficient directive force to overcome the friction between the cap and bearing point, otherwise the compasses would have been sluggish, and would not have indicated accurately and quickly any changes in the ship's head. Another important reason for making the magnetic moment as small as possible, is to allow of an accurate correction being made of one part of the error of the compass, called the quadrantal error, which is produced by the iron of the ship. When large compass needles are used, this correction is vitiated by the inductive action of the large needles on the soft iron correctors. To allow of the whole compass error being really well corrected by means of magnets and soft iron of convenient size, it is necessary that the needles should have a small magnetic moment, and that they should be as short as possible, consistent with their being powerful enough not to allow of any frictional error.

One of the first to note the effect produced on the Mariner's Compass by the iron used in the construction of ships was Wales, the astronomer of Captain Cook's voyages; but no systematic attempt was made to investigate the subject until the beginning of the present century, when Captain Flinders, an officer in the Royal Navy, made a voyage to Australia. He observed that there was a difference in the indications of the same compass, amounting to as much as 4½ degrees, when placed in different positions in the same ship; and, further, that with the compass in the same position its indications differed when the ship's head was in different directions. He found that with the ship's head north or south no deviation was produced, but that with the ship's head east or west there was a maximum deviation. In the northern hemisphere, with the compass placed in the ordinary position near the stern, he found that the north point of the compass card was attracted towards the bow. On proceeding south he noticed that this attraction of the north point of the compass card towards the bow diminished gradually, and that at the equator there was no attraction from the iron of the ship. In the southern hemisphere the effect of the iron of the ship was reversed, and the north point was found to be repelled from the bow of the ship. The iron in such vessels as Captain Flinders's—namely, wooden sailing ships—was principally employed in the shape of vertical rods for stanchions, and would be of the quality known as soft iron.

There are two qualities of iron, which are differently affected when brought under magnetic influence—soft iron and hard iron.

Soft iron is iron which becomes magnetised almost or quite instantaneously when brought under the influence of a magnetising body, and which loses its magnetism as soon as that influence is removed. Hard iron, on the other hand, does not acquire magnetism so easily, but when once it is magnetised it retains it permanently, even after the magnetising force is removed.

I have here a piece of soft iron, and when I hold it in a vertical position you will observe that the upper end attracts the red end of this suspended needle; the lower end attracts the other pole. Now I will reverse the bar end for end, and you will see that the lower end, which formerly was up and attracted the red end, now repels it and attracts the opposite end, and the end which is uppermost now attracts the red end instead of repelling it. Thus, by simply reversing the bar end for end, the magnetism in it has been reversed. Further, if I hold it in an east and west direction, it will not produce any effect on the needle, provided the bar is very soft. If I strike the bar while in a vertical position, the magnetism will become to a certain extent fixed, so that when I reverse it end for end, the magnetism in it does not at once become reversed. On the contrary, you will see that the upper end now repels the red end, instead of attracting it as formerly. If I leave the magnet hanging in this position for some time, it will gradually lose the magnetism which was hammered into it, or I can knock the magnetism out of it at once by striking it gently. But if I take a bar of soft iron, large enough in diameter in proportion to its length, I cannot make the magnetism in it become fixed by striking the bar. This fact, we shall see, is of considerable importance in the correction of one part of the error of the compass caused by the iron of the ship. This bar, when held vertical, is influenced by the earth's magnetic force, and becomes magnetised by induction as it is called. The lower end which is towards the North Pole takes magnetism of the opposite name, or true southern polarity, or becomes a red pole. The upper end takes magnetism similar to the earth's North Pole, or true northern polarity, or becomes a blue pole. The earth in this case is the magnetising body.

When the bar is held horizontally in an east and west direction, there is no magnetic force acting in the direction of the length of the bar, and consequently the bar does not perceptibly show any magnetic properties.

We will now return to the consideration of Captain Flinders' observations. I have told you that in the northern hemisphere he found an attraction of the north point of his compass needle towards the bow, in the southern hemisphere towards the stern. His explanation of this was that the vertical iron of his ship became magnetised by induction from the earth. In the northern hemisphere the upper end of all the vertical iron attracted the north point of his compass. At the equator, where there is no vertical magnetic force of the earth, no effect was produced by the iron. In the southern hemisphere, where the earth's vertical magnetic force is reversed from what it is in the northern hemisphere, the upper end of the vertical iron repels the north point of the compass.

As the compass in the old sailing ships was placed near the stern, there would be a larger amount of iron before the compass than behind it, and as the compass was placed on deck, the upper parts of the iron would be nearer the compass needles than the lower parts. Therefore, in the northern hemisphere, the north point would be attracted towards the bow, and in the southern hemisphere towards the stern.

Captain Flinders not only gave the correct explanation of the effect of the iron on the compass, but he also proposed a method of correcting the errors thus produced, which is of great utility in the correction of compasses of the iron ships of the present day. He suggested that a bar of soft iron should be fixed in a vertical direction before or behind the compass to counteract the effect of the induced magnetism of the iron of the ship.

Captain Flinders dying shortly afterwards, the subject received little attention until about the year 1817, when Professor Barlow engaged in a series of most interesting experiments on the effect produced on a compass needle by masses of iron, magnetised by induction from the earth. These researches were undertaken with a view of correcting the errors of the compass caused by masses of iron such as guns, and one result of the greatest importance which Barlow obtained, was that the effect produced on the compass by a hollow globe is the same as that produced by a solid one, provided there is a certain thickness in the metal of the hollow one in proportion to its diameter. He proposed to correct the deviations of the compass by applying a circular plate of soft iron, which would produce errors of the same amount as the deviations produced on the compass by the iron of the ship. This method was applied to some ships in the British Navy with success, but the introduction of iron into the construction of the hulls of the ships shortly afterwards completely altered the problem, and other methods had to be adopted in consequence.

In the year 1824, Poisson, the distinguished French mathematician, published a mathematical investigation of the theory of magnetic attraction and repulsion, and discussed the magnetic actions on a horizontal needle of the earth directly and of iron globes rendered magnetic by the inductive action of the earth. In 1838, he adopted the results of his previous investigations to observations made on board ship, for the purpose of determining the errors of the compass caused by masses of iron symmetrically placed on each side of the fore-and-aft section of the ship. These investigations of Poisson furnished the basis for the further development of the mathematical theory of the deviation of the compass on board an iron ship. But he had purposely confined himself in his investigations to the case of transient induced magnetism in soft iron, and had omitted what soon after his time became of the greatest importance, namely, the action of the ship as a permanent magnet.

So far, we have been considering the deviations in wooden ships, in which the iron used was of small amount, and almost entirely of the nature of soft iron. The deviations found in these vessels were small in amount.

We now come to the period when iron began to be used for the construction of ships, and large masses of iron for the machinery of steamships.

In 1838, Sir George Airy, the late Astronomer Royal, undertook, at the request of the Board of Admiralty, a series of experiments on the deviations produced on the compass on board two iron vessels, the *Rainbow* and *Ironsides*, for the purpose of discovering the laws which govern the disturbance.

The results which he obtained from these experiments, and the mathematical theory of the magnetism of an iron ship which he deduced from them, were given to the Royal Society in 1839. In this important paper he showed how the errors of the compass, depending on the influence of the magnetism of the ship, may be perfectly corrected by steel magnets and masses of soft iron placed in the neighbourhood of the compass. His system of correction of the compass was pretty generally adopted in the merchant service soon after it was proposed, and now it is universally employed, not only in the merchant service but also in the navies of this and other countries.

Since the time of Sir George Airy's experiments on board the *Ironsides* and *Rainbow*, our knowledge of the problem of ships' magnetism has been largely increased. Airy himself continued his investigations for many years, and communicated his results in papers to the Royal Society.

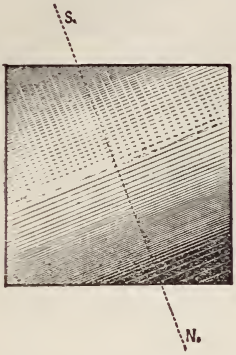
The late Mr. Archibald Smith, an eminent mathematician and lawyer, in addition to his professional work as a barrister, devoted himself for many years with great energy to the advancement of this question. By transforming the orginal equations of Poisson to a more practical and simple form, he was able to devise a system of correction and harmonic reduction of the observations of the compass which has been of the greatest service, not only in the branch of practical science for which it was originally intended, but also in many other departments of practical physics. In conjunction with Sir Frederick Evans, the late Hydrographer of the Admiralty, he revised the Admiralty Instructions regarding the compass, which in their new form appeared as the "Admiralty Manual on the Deviations of the Compass." This important work has been appreciated not only in this country, but throughout the civilised world. It has been translated into Russian, French, German, and Portuguese, and has also been adopted by the Government of the United States. Having referred to the work of Sir F. Evans, I may take this opportunity of giving expression to the regret which must be felt by all interested in the navigation of iron ships on account of his recent death. The communications he made to the Royal and other societies on the subject of the magnetism of iron ships were of great value.

In addition to Airy, Archibald Smith, and Evans, the names of Sabine, Scoresby, Captain Johnson (of the Compass Department of the Admiralty), Towson and Rundell (secretaries of the Liverpool Compass Committee), must always be mentioned with gratitude for the services they rendered in the elucidation of the compass problem after the introduction of iron ship building. In France, Lieut. Collet, of the French navy, has devoted much attention to this subject, and has recently published a very valuable theoretical and practical treatise on the compensation of the compass, with or without bearings.

When considering the magnetic properties of an iron ship, it is convenient to imagine the iron divided into classes, hard iron and soft iron; not that any of the iron or steel used in the construction of ships is either perfectly hard or perfectly soft. Any ordinary plate used in the construction of a ship, whether it be iron or what is called steel, will become magnetised by induction from the earth, and if subjected to concussion from hammering it will become more highly magnetised, and retain a portion of that magnetism in a permanent condition.

Let us consider the case of an ordinary plate of iron, as shown in the diagram (Fig. 1, p. 235), placed upright in the magnetic meridian in the Northern Hemisphere. The upper edge, from end to end, will be found to attract the north point of the compass card, or to have acquired blue magnetism, while the lower edge will attract the south point of the compass card, or it will have acquired red magnetism. Between the top and the bottom there will be a neutral zone running along the length of the plate, and this zone will be inclined to the horizon. In a square plate its direction will be at right angles to the dipping needle at the place of observation, but in an oblong plate its direction will be more in the length of the plate. Now if this plate were to be hammered, as is done when it is rivetted into a ship, it would acquire some permanent magnetism, so that in whatever position it were held it would indicate a distribution of magnetism similar to what is shown in the diagram (Fig. 1). But superimposed on this permanent magnetism there would still be magnetism induced by the magnetic force of the earth.

FIG. 1.*



Now what I have described for one plate takes place during the construction of an iron ship with each plate. The result is that the whole ship becomes magnetised, and the distribution of that portion of the magnetism which is thus hammered into the ship depends on the direction of the ship's head while building.

It was Dr. Scoresby who first called attention to the remarkable fact that the magnetic character of a ship depends essentially on the direction of her head while building, and that this original magnetism is subject to great changes after launching. The diagram (Fig. 2, p. 236) shows the distribution of this magnetism, which is usually called the permanent magnetism, for ships built in this country with their heads in the directions North, South, East, and West. In the upper drawing, the ship is represented as having been built with her head magnetic North. In this case, the upper part of the stern being farthest from the north, acquires blue magnetism strongly, while the lower part of the bow acquires red magnetism strongly. Between these extremes, there is a neutral zone running from the upper part near the bow to the keel near the stern post. The intensity of the blue and red magnetism of the stern and bow gradually diminishes towards this zone. In such a ship the north point of the compass will be attracted towards the stern, and the south point towards the bow.

The next drawing represents a ship built head magnetic South. Here we have the upper part of the bow a powerful blue pole, while the lower part of the stern is a powerful red pole. In this case, the north point of the compass will be attracted towards the bow.

With the ship built head East or West, the whole upper part of the ship will have blue magnetism, and the lower part red magnetism; but in the former case, the starboard side being further from the north will be more powerfully blue than the port side, so that the north point of the compass card will be attracted to the starboard side. Whereas with the ship built West, the port side will be more powerfully magnetised than the starboard side, and the north point of the compass card will be attracted to the port side.

The resultant of all the magnetism thus acquired gives rise to a single disturbing force of the same character as that which would be produced by a permanent steel magnet. I have spoken of this part of the magnetism of the ship as permanent magnetism. It is permanent in direction, but it is liable to change in amount with time, especially so when the ship is new. The change is greatest just after launching, and if the ship is then turned round and kept with her head in the opposite direction to what it was before launching, a large part of the magnetism which is not firmly hammered into the iron will be lost. It is most important that every new ship, after launching, should be turned round and kept with her head in the opposite direction while fitting out for sea, so that she may lose as much as possible of the magnetism which has not been firmly hammered into her before having her compasses adjusted. This is a matter which is very much overlooked at present. It is most desirable that naval architects or others who superintend the construction of iron ships should insist on having it done. I would suggest that a clause should be added to all the contracts for new ships, that after launching, the ship should be turned round and kept,

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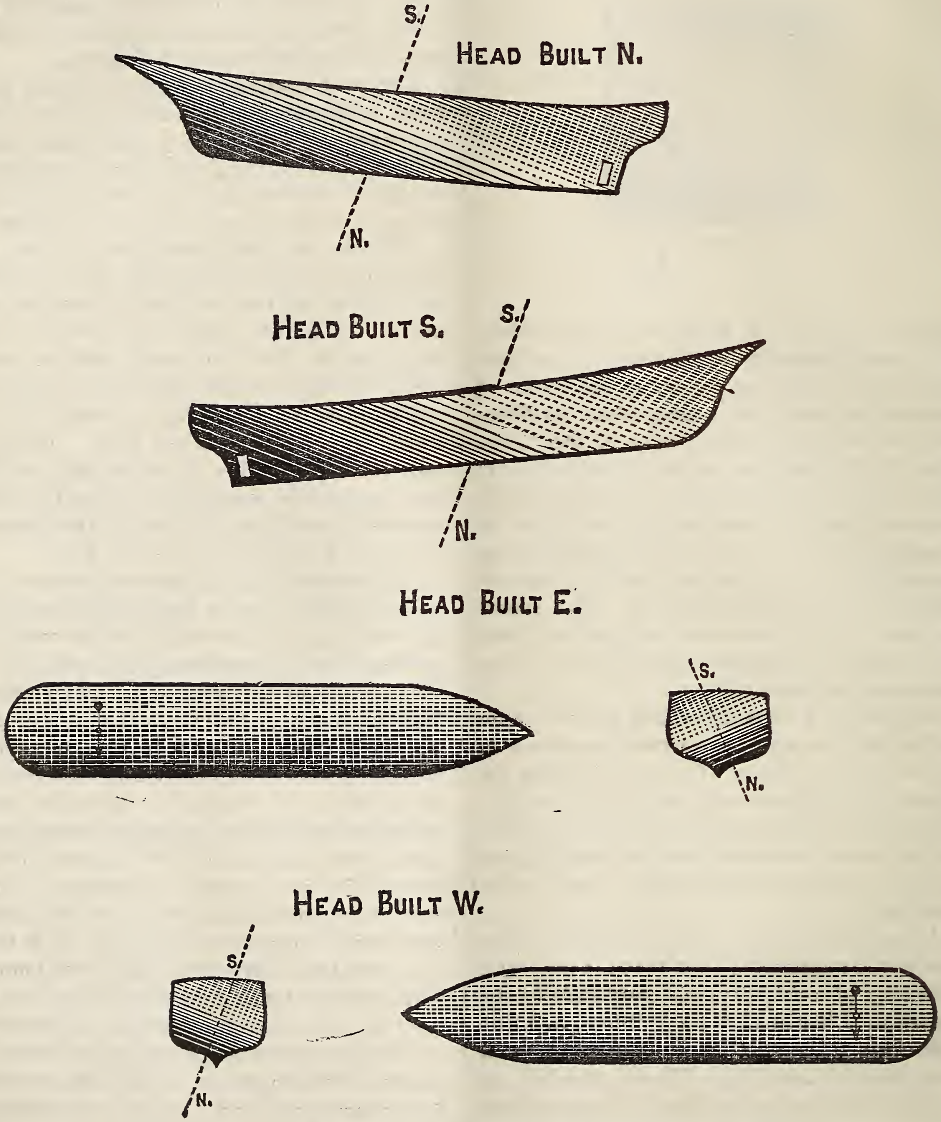
* In these diagrams the blue is marked by the cross lines, the red by single lines.

Fig. 2.



Permanent Magnetism of Ships.

while fitting out, with her head as nearly as possible in the opposite direction to what she was on the stocks. I have known many cases where this has not been attended to, in which the magnetism changed so much within a few days as to cause serious inconvenience and danger in the navigation of the ship. One instance which came under my notice a few years ago, will show the importance of having the ship turned round. A large passenger ship was built with her head nearly south, and fitted in the same direction. Her compasses were carefully adjusted, and after that she remained swinging to her anchor in a tide way, so that ead turned to different directions each tide for a week. Before she left for her first voyage, I went on board to ascertain the errors of her standard compass, as I expected to find a considerable change. I found on some points there was as much as

10° of difference of error from what there had been a week before. The ship, by swinging to her anchor for a week, had lost an amount of magnetism sufficient to produce an error of ten degrees on the compass. Since that time several other ships similar in every way have been built by the same builders for the same company, but they have been turned round after launching, and there has been comparatively little change in their magnetism. The importance of this was pointed out thirty years ago by Dr. Scoresby, and recommended by the late Sir Frederick Evans, but shipbuilders and others are in much need of being reminded of it now.

The effect of the magnetism of the hard iron is to produce an error on the compass which vanishes when the ship's head is on two opposite points, and attains a maximum amount in each semi-circle as the ship turns round. It has, therefore, been called a semi-circular error. I may illustrate the effect of the permanent magnetism of the ship by fixing a steel magnet on this frame, and turning it round the compass. The frame will represent a ship in which the magnetism is altogether permanent magnetism. When the line of the disturbing magnet is in a line with the compass needles, no deviation is produced. As the ship's head is turned round the deviation increases, until it attains a maximum, when the line of this disturbing force is at right angles to the compass needles. It then gradually diminishes and again comes to zero. Continuing to turn the ship, we find a deviation again appears, but in the opposite direction to what it was in the other semi-circle. It attains a maximum, and comes to zero at the place of starting.

You will now readily understand that as this magnetism which is hammered into the hard iron of the ship gives rise to forces, the resultant of which is a single magnetic force acting in a definite direction in the ship, its influence on the compass may be neutralised by placing a steel magnet with its poles in the opposite direction, at such a distance from the compass that it will exactly counterbalance the magnetism of the ship. This is one of the plans which Sir George Airy proposed in 1838, and which is used for correcting the standard compasses in the Navy. The amount and direction of the ship's permanent magnetism at the position of the compass is first determined. A steel magnet is then selected, and the distance found by trial where it will produce the same force on a compass needle as the ship's magnetism does at the position of the compass on board. A hole is bored in the wooden stand at the right distance from the compass needle, and the magnet inserted with its poles acting in the opposite direction to the ship's magnetism.

The second of Sir George Airy's plans, and which is the simplest and most convenient, is generally adopted in the merchant service. It is to apply two sets of magnets, one set fore-and-aft, and the other set thwartship to counterbalance the fore-and-aft and thwartship component of the ship's magnetism.

We have now to consider the action of the soft iron magnetised by induction from the earth, and it is necessary to divide this into two parts—the magnetism induced by the earth's vertical force, and the magnetism induced by the earth's horizontal force.

All the vertical iron of the ship becomes magnetised by induction from the vertical component of the earth's magnetic force. In the northern hemisphere, the upper parts of the vertical iron attract the north point of the compass card; in the southern hemisphere the south point. The effect of vertical iron on the compass may be illustrated by moving a vertical rod of soft iron round the suspended needle. Let the bar be kept with its upper end about the same level as the needle. Now, in whatever position the upper end of the bar is held, the north point will always be attracted towards it. Consequently, when the bar is held in the line of the needle, there is no deviation, but when it is in a line at right angles to the direction of the needles a maximum error is produced, which is easterly when the bar is to the east of the needle and westerly when it is to the west. Thus we have a semi-circular error produced by a vertical bar carried round the compass. All the vertical iron acts similarly, and produces a semi-circular error as the ship is turned round in azimuth. The amount of this error will vary in the same ship according to the position of the compass with regard to the vertical iron. In some positions, where the iron is symmetrically distributed fore-and-aft, and also athwartship, the attractions on opposite sides may neutralise each other, and no error will be produced, while in other positions there may be large errors. For a compass in the same position in the ship, the error will vary in different parts of the world as the vertical force of the earth changes.

The force on the compass due to magnetism induced in the soft iron of the ship by the vertical component of the earth's magnetism is constant in direction in the ship, but it varies in amount in proportion to the earth's vertical force. The error which it produces on the compass varies, therefore, directly as the earth's vertical force, and inversely as the earth's horizontal force, or, what is the same thing, directly as the tangent of the dip.

The error caused by induction in vertical iron is usually corrected along with the permanent magnetism by means of steel magnets. This plan is objectionable, except for ships trading in the same latitude, because the earth's vertical force, which produces the error varies in different parts of the world, whereas the force applied to correct it remains constant. This error is really the same as that observed by Captain Flinders in his wooden ship, and the proper way to correct it is that which he suggested, namely, a bar of vertical soft iron placed in such a position as to produce a force on the compass needles equal and acting in an opposite direction to the ship's force. The Liverpool Compass Committee had such a bar fitted to the steering compasses of several ships, and Captain Lecky has applied it with remarkable success to the compasses of several ships in the merchant service. The binnacle of Sir William Thomson's compass is fitted with a brass tube for holding this Flinders bar, and whenever the requisite information can be obtained for determining the size of bar required for any particular compass in a ship it is applied.

The application of the Flinders bar has been of great service in a large number of ships. It is particularly useful for mail steamers making regular passages between this country and the Southern Hemisphere. In such cases, after the ship has made one or two voyages, it is quite possible to adjust the length of the bar so that the change in error from vertical induction will not exceed two or three degrees in going from England to the Cape of Good Hope.

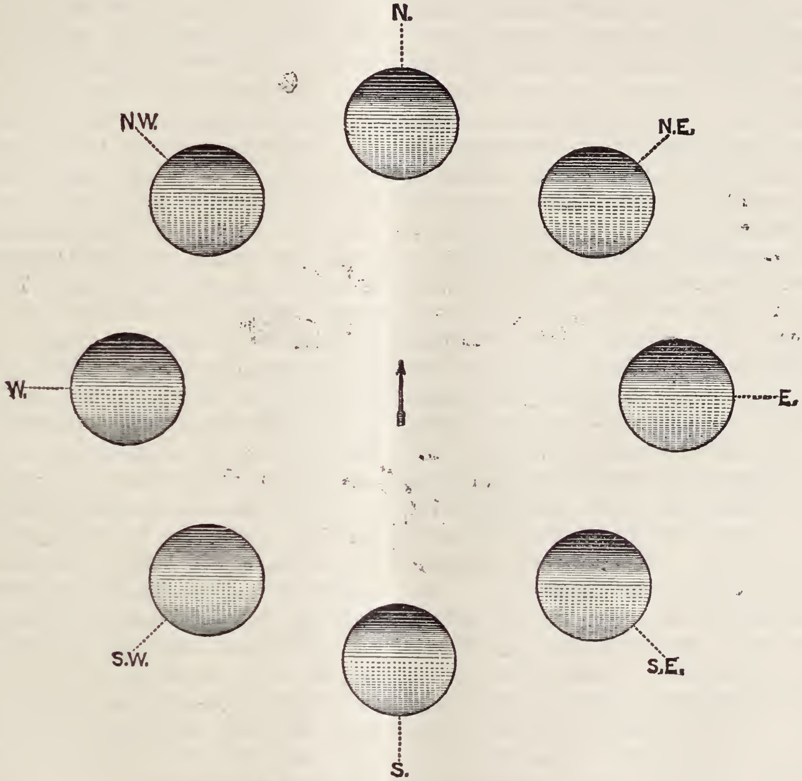
When a compass is placed in a new ship, it is impossible to tell with accuracy how much of the semicircular error should be corrected by Flinders bar, and how much by steel magnets. To determine the amount of Flinders bar required, it is necessary to have observations of the deviations in two places differing considerably in magnetic latitude. But even in a new ship an experienced adjuster can generally place a bar so that there will at all events be less change with change of latitude than if the whole semi-circular errors were corrected with steel magnets. Similar ships with the compass placed in similar positions will generally require about the same amount of Flinders bar. As an illustration, I may refer to the Donald Currie mail steamers between London and the Cape. Ten ships for this line have been supplied with the binnacle fitted with the receptacle for the Flinders bar. It has been found, after making one or two voyages to the Cape, that in all these ships the Flinders bar is required to be placed on the fore-side of the binnacle, and that the amount of error to be corrected in London varies from ten to fifteen degrees. In six of the ships the error to be corrected was 13 degrees. Now, in any other new ship similar to these, and with the compass similarly placed, it would be quite safe to apply a bar at the first adjustment to correct about 13 degrees in London. If the whole semicircular error in these Cape mail steamers were corrected in this country by steel magnets, there would be a change in the deviations on east and west courses of from 16 to 24 degrees every voyage to the Cape. The application of the Flinders bar diminishes the amount of change in deviation by that amount. In order that the Flinders bar may not give rise to error through becoming permanently magnetised, it should be large enough in diameter in proportion to its length not to become magnetised by hammering.

We have seen that the permanent magnetism of the ship and the induced magnetism from the earth's vertical force both produce an error of the same nature as the ship's head is turned in azimuth, namely, a semi-circular error, but the deviation produced by the induced magnetism from the horizontal force follows a different law.

In this case, as the ship is turned round in azimuth, the direction of the force on the compass due to magnetism induced by the earth's horizontal magnetic force remains fixed with regard to the earth's magnetic meridian, but changes with respect to the direction of the ship's head. With the permanent magnetism, and with the magnetism induced in vertical iron, the direction of the disturbing force remained constant in the ship and therefore varied in space as the ship turned round, but with the magnetism induced in horizontal iron the direction remains constant in space. Let us see how this affects the compass.

It may be illustrated by this arrangement. In this cradle there are two hollow globes of cast iron, with their centres on a level with the compass needles. The result is that the magnetism induced by the vertical component of the ship's magnetism does not affect the compass, and the whole disturbance is caused by horizontal magnetic force. This will represent an actual ship with regard to its horizontal magnetic force, with a compass placed on the central fore-and-aft line, so that the iron is symmetrical on each side. Now, as the globes are turned round the compass needle, the induced magnetism in the globe changes in direction with respect to a fixed meridian of the globe. The line joining the centre of the globes will represent the length of the ship. I will now turn the cradle containing the globes. When the line joining the centre of the globes is North and South, the northern parts of the globes will acquire red magnetism and the southern portions blue. In this position no deviation is produced, because the resultant of the horizontal lines of magnetic force will be in the magnetic axis of the compass, but the force acting on the compass needles will be increased. As the northern globe is turned towards the East, the north point of the compass card will be drawn towards the east, and the deviation will increase until the direction of the globes is N.E. From this point the deviation gradually diminishes until the globes become East and West, when no deviation is produced, but the directive force acting on the needles is diminished. Now, as we turn the globes further round, the north point of the compass card will be drawn towards the west, and the deviation will increase until the globes are S.E. and N.W. It then diminishes until the globes are in the North and South line, when there will be no deviation, but the force will be increased. Continuing the operation in the other semicircle, we shall obtain a repetition of these results. With the globes S.W. and N.E. easterly deviation will be found, with the globes East and West there will be no deviation, and when the globes are N.W. and S.E. there will be westerly deviation. The effect of magnetism induced from the horizontal force of the earth may be illustrated by the diagram (Fig. 3) which represents a horizontal plate of iron placed in different positions

Fig. 3.



Induced Magmetish from Horizontal Force.

round a compass needle. Thus the magnetism induced by the earth's horizontal force causes a deviation which attains a maximum in each quadrant, and is of opposite name in each adjoining quadrant. It has, therefore, been called quadrantal error.

Now the magnetic force which causes the quadrantal deviation being induced by the horizontal force of the earth, its magnitude is proportional to that horizontal force, and as the directive force on the compass needles is also proportional to the same horizontal force, it follows that the deviations produced by the magnetism induced in horizontal iron are independent of changes in the earth's force, and will be the same in all parts of the world. The quadrantal error is corrected by placing masses of soft iron on each side of the compass. As a rule, where a standard compass is placed in the centre line of the ship, the iron is symmetrically placed on each side of the compass. In such cases the quadrantal error vanishes on the four cardinal points N. E. S. W., and attains a maximum easterly deviation at N.E. and S.W., and a maximum westerly deviation on N.W. and S.E. It is corrected by placing the soft iron on each side of the compass, in the thwartship line. The soft iron may be in the form of iron chain, or cast-iron cylinders, as proposed by the Liverpool Compass Committee; or iron spheres, as used by Sir William Thomson. There is an objection to the use of chain, particularly when used with powerful compass needles; the links may become permanently magnetized from being too close to the ends of the needles.

In some exceptional cases, when the iron is not symmetrical round the compass, we may also have a quadrantal error which has a maximum on the four cardinal points, and vanishes on the four quadrantal points. This occurs in some of the turret ships, but it is so uncommon in ordinary ships, that it is not necessary to go fully into it now. It may be corrected by placing the soft iron on opposite sides of the compass, obliquely to the thwartship line. In these exceptional cases there is usually a small constant error of the same name on all courses remaining, which must be allowed for.

Since the quadrantal error remains the same all over the world, and does not alter with time to any appreciable extent, it is very desirable to have it properly corrected at first. When it is properly corrected, the re-adjustment of the steel magnets from time to time, as errors arise from change in the permanent magnetism of the ship, becomes very simple.

Hitherto I have only considered the case in which the ship is supposed to be upright, but when the ship heels over other influences come into action which produce errors, often of a very serious amount. The greatest errors from heeling occur in iron ships when they are upon Northerly or Southerly courses. When the ship's head is East or West, there is no heeling error. In general, with ships built in the northern hemisphere, the north point of the compass is drawn towards the high side of the ship while in northern latitudes. The error is usually greatest when the ship is built with her head in a northerly direction. In such ships the heeling error diminishes on going towards the southern hemisphere. With ships built in a southerly direction, if the compass be placed near the stern, the heeling error is usually small, and in some cases the north point is drawn to the low side of the ship. When the latter cases occur, the heeling error will increase as the ship proceeds to the south. The heeling error may be corrected for any particular latitude, by placing a magnet, which is vertical when the ship is upright, and becomes inclined to the vertical as the ship heels over, under the centre of the compass at such a height as to neutralise the ship's vertical force.

Although the compass on an iron ship may be accurately corrected at any particular time and place by the methods which I have briefly described, it would be a great mistake to suppose that the indications of the compass can be depended on for any length of time afterwards without constantly ascertaining the errors by means of observations. In every ship, whether old or new, but especially in a new ship during the first years, the only safe plan is to expect the errors to change, and never to lose an opportunity of checking the indications by observations of the sun by day, and stars by night.

It cannot be too often impressed on those who have the charge of iron ships that the Mariner's Compass is no trustworthy guide, placed as it in the midst of such changing forces as the magnetism of an iron ship. I have already referred to the changes which occur in the magnetism of new ships, and which may give rise to serious errors. No doubt the amount ot change diminishes in time, and after some years the magnetism of the ship becomes, to a certain extent, constant, but it is always liable to alteration by shocks from the sea or other causes.

The only definite and scientific information which has been obtained regarding the changes in the magnetism of ships during the last thirty years has been supplied by the Compass Department of the British Navy. An interesting paper has recently been given to the Royal Society by Captain Creak, F.R.S., on the deviations of the compasses of certain classes of her Majesty's Navy, in which he has recorded the magnetic history of a large number of iron armour-clad, iron and composite ships. The Tables which are appended to his paper show that, after a few years' service, the magnetism due to the hard iron becomes to a very great extent permanent, but I do not think that it would be safe to expect the same result with ships of the merchant service. The ships of the navy are constructed of much thicker plates than those of the merchant service, and we may suppose that the vibration from the engines and shocks from the sea would have a greater effect in producing a change in the magnetism of the latter. Another reason for expecting the standard compasses to act more satisfactory in the ships of the navy is that the greatest care is exercised by the Compass Department in the selection of the best possible position for the standard compass, with respect to the surrounding iron; whereas in the merchant service, in many cases, no precautions are taken for the selection of a good position for the standard compass.

I have now to refer to another part of the magnetism of the iron which in many ships plays an important part, and gives rise to deviations which are frequently very puzzling to the navigator. This is called by some writers "Retentive Magnetism," but perhaps a better name for it is sluggishness of the ship's magnetism. It is the error which is found when a ship's course is changed after having been steaming in the same direction for some days. The error is also found after a ship has been lying in the dock for a considerable time. This is particularly observable in vessels trading between this country and North America. It frequently happens on the voyage from here to New York, after steaming for five or six days on a westerly course, when the vessel's head is turned to the north, an error of several degrees of westerly deviation is found. On the other hand, after coming from New York to this country steering for several days on an easterly course, when the ship's head is turned to the north, an error of several degrees of easterly deviation is found.

It may also be observed with ships going to India. After steaming along the Mediterranean in an easterly direction, when the ship's head is turned to the south, westerly deviation is frequently found; but when coming home, after passing through the Mediterranean steering west, when the ship is turned to the north, westerly deviation is found. If the ship be kept for a few days on the second course, the error will gradually diminish. The explanation of this is that the ship acquires some additional magnetism, which becomes temporarily fixed by the shaking from the screw and shocks from the waves. So long as the ship remains on the same course, no deviation from this cause is produced on the compass, but as soon as the course is altered, the side of the ship which was farthest from the north having acquired a dose of blue magnetism, attracts the north point of the compass, and produces the deviation observed. Now this magnetism, not being firmly fixed into the iron of the ship, is gradually shaken out when the ship is on another course. The amount of this error cannot be predicted at all. Captain Lecky has found it to amount, in some cases, to as much as 10 degrees after steaming in an easterly or westerly direction for six or seven days. The following rules have been given by Sir William Thomson as a warning regarding the sluggishness of ships' magnetism :—

1. After steering for some time on westerly courses expect westerly error if you turn to the north, or easterly error if you turn to the south.

2. After steering for some time on easterly courses expect easterly error if you turn to the north, or westerly error if you turn to the south.

In conclusion, I may just give a few words of warning on a point of considerable importance in connection with the electric lighting of ships, and the action of the current of electricity on the ship's compasses. During the last few years many passenger steamers have been lighted with electricity, and often only a single wire is used, the ship's side taking the place of the return wire. Now, in such cases it is quite possible that the wire may be placed in such a position and at such a distance from the compass that the current flowing through it will produce a large error.

Take, as an example, a main lead from the dynamo machine, to light up a saloon with 100 lamps, or more. It may run along nearly underneath the position of the standard compass. The current may be taken at 100 ampères. In such a condition of affairs, the error produced on the compass will amount to as much as 7½ degrees when the wire is at a distance of 30 feet. Now this error will only be produced at the time that the current is flowing to light up the lamps, and it may never be detected by the officers of the ship. The observations for determining the error of the compass are usually made during the day, when the electric light is not required. The captain may therefore determine his compass error every day, and set his course quite correctly, but for some hours at night the ship may be going several degrees off her proper course, although she is being steered correctly by the compass.

This refers to a single wire system, and a continuous current machine, but if an alternate current machine be used, no effect will be produced on the compass, even with a single wire, and the ship's side as a return. Also with a continuous current machine the danger may be entirely avoided by using a double wire system with the two wires close together. It is essential that both wires should be well insulated from the ship's side. A want of insulation in one of the wires, although there may be no change observable in the lighting, may produce as much error on the compass as if there were only a single wire. So far as I know, there is no great advantage in the single wire system over the double wire, except it be a slight saving in the first cost. It would, therefore, appear that for the safety of the ship, when a continuous current machine is used for lighting, two wires, well insulated, should always be employed, and that the insulation of the wires should be tested periodically to make certain that no fault has occurred.

DISCUSSION.

Mr. Alexander Siemens said he should like to say a word or two with regard to the single wire system of lighting ships. His firm had fitted a great number of ships, both on the single and double wire system, and with both alternate and continuous current machines. With one exception there had never been any effect produced on the compass, and that was one in which the compass was put up after the electric light, and it was, by mistake, put too near to a wire. They offered to remedy this at once, as it only required a return wire alongside the leading wire, but the captain said that he was quite satisfied, as on swinging his ship, he had made careful observations with the lights on and off, and he knew what the compass would do, and he did not want his cabins pulled about. He had read Mr. Bottomley's article in the *Nautical Magazine*, in which he gave the details of how he arrived at the fact that a current of 100 ampères passing 30 ft. from a compass could produce an error of seven deg.; but he had left out of consideration entirely that the ironwork of a ship could serve as a magnetic screen, so that, in point of fact, whether the current of 100 ampères were passing through the wire or not, there would be absolutely no effect on the compass. In some ships of the White Star Line they had actually lighted the binnacle of the compass with the electric light, and had used the metal work as the return, and there had not been the slightest deviation. But even if error were produced it was a perfectly observable one. Mr. Bottomley had pointed out that the captain should be careful in comparing the indications of his compass with the astronomical north, so as to be always sure that the compass arrangements were in working order; therefore, if the ship were lighted with the electric light, all that was necessary was to call the captain's attention to it. When he was correcting his compass and swinging the ship, he might as well turn the electric lights on and off so as to take their influence into consideration, as well as that of permanent magnetism, and so on. Mr. Bottomley attached great importance to the insulating of leading wires, in which he quite agreed with him, but he could not agree with him that the single wire system had no advantage except that of being cheaper. If there were only a single wire to deal with it was much easier to insulate that well, and you could arrange the fitting of the lamp and everything much more satisfactorily, and make the insulation much safer is there were only one wire to insulate than two. In all these matters the proof of the pudding was in the eating, and they had fitted up vessels for the Cunard, the P. and O., the White Star, and numerous other lines, and for all these companies they had used both the double and the single wire system. All the practical men, and they had also taken scientific advice, preferred the single wire, which had never caused any difficulty, with the one exception, alluded to above, where the compass was put up after the electric lighting installation was complete. Their assistants had always special instructions when testing the electric lights to observe the compass, and make sure that there should be no effect produced upon it; but with regard to currents which were at all distant from the compass, the iron of the ship had always been found an effective screen.

Commander Creak, R.N., said the electric light had been used in the Royal Navy for some time, and the greatest disturbance of the compass was produced by the generating machine. They had tried one of Edison's machines in the *Euphrates*, and so far from the ship being a magnetic screen, its influence was felt through a distance of 55 ft., including the iron bulk heads. All the evidence went to prove that the ship was not a magnetic screen at all. With one exception all the ships were on the double wire system, and there was no trouble in that respect. The only one in which a single wire was adopted, and the hull used as the return, was the *Polyphemus*, but the most recent experiments in her proved that no deflections of the compass was caused. Some more recent experiments on shore, however, proved that at a distance of 30 ft. you got 5° or 6° deflection from a single wire and a current of 100 ampères. It was, therefore, a point to be looked to in all installations on board ship that the wire, if not doubled, should be kept at a considerable distance from the compass.

Captain BEALL said he could scarcely agree with Mr. Bottomley that the reason why so little interest was taken in this subject, and why it was so little understood, was because the books written on the subject were in a too mathematical form to be intelligible to ordinary readers. That might be so to some extent, but there were some very simple and plain books now issued, such as "Towson's Practical Information" and other works. At the same time he did not think that works alone, however clear, would give such a good conception of magnetism as seeing the effects actually produced on the compass needle. Some five or six years ago it occurred to him that if it were possible to devise some instrument which would show the effects on the compass of subpermanent magnetism, the iron beams of the ship, the vertical iron, and also how these errors could be compensated by magnets and soft iron, it would be a very valuable acquisition, especially for teaching candidates, and examining them. Some time ago he saw some statements in the *Nautical Magazine* and gathered from other sources, that there were one or two valuable instruments which showed everything very clearly, but when he inspected these instruments, he found they were very far from perfect; in fact, they showed nothing more than the permanent magnetism, and the necessary compensation, which was the simplest part of the problem. Having failed to find a perfect instrument, he thought he would try and devise one himself. At first he made a model about two feet long, and one foot broad, but when fitted up with magnets, he found it was too small to work properly, as the magnets, iron, &c , being so near together, produced abnormal deviations. He then made another about 3 ft. 6 in. by 2 ft., and that was, he considered, perfect. It showed also the whole of the components of the heeling error very graphically, not only those arising from the beams and stanchions, but also from the permanent magnetism, and the mode of correction. He thought scarcely sufficient credit had been given in the paper to the work done by Mr. Rundell with regard to the vertical bar. Of course. Captain Flinders was the original proposer, but that was only with regard to wooden ships. When Mr. Rundell was secretary to the Liverpool Compass Committee, he introduced an iron bar into fifteen ships with remarkable success, but this was something more than a Flinder's bar, as it was a hammered one, and specially prepared for the purpose, and when possible was made an integral part of the ship. He thought the mercantile marine was very much indebted to Mr. Rundell.

Prof. AYRTON, F.R.S., said he was not prepared to say much on this subject, for though he was acquainted with almost every device of Sir William Thomson's, including his sounding machine, he had never had an opportunity of using his compass. He felt certain, however, that if by using light and comparatively small magnets he had obtained as much success in the mariner's compass as he had in his electrical apparatus, where also he used very light magnets, nautical men must have much to thank him for. In the beginning of the paper a good deal was said about magnetism. At the present time it was the fashion to go into the question of nomenclature, in fact, a committee was now sitting in London for the purpose of endeavouring to arrive at some unanimity of scientific names in connection with electricity and magnetism. No doubt Sir George Airy's suggestion of red and blue magnetism was very simple, but he confessed he could not accept it, because there was nothing really red or blue in magnetism, and he saw no special reason for using these names instead of the much better known ones of north and south. No doubt there was a difficulty about the names. When he was a student of Sir William Thomson's, and for some time after, he always called the north-seeking pole the true south pole, and the south-seeking pole the true north pole, but this was rather confusing. Then he rather dropped into calling the pole which pointed to the north the north-seeking pole, and the same with the south pole; then by degrees the word "seeking" dropped out, and he ended by calling it the north pole like everybody else in this country. The question was, was there any better name? He thought there was a very simple one. All instrument makers put a mark on the north-seeking pole, then why not call the pole which pointed to the north the "marked pole," and the other the "unmarked pole"? There would be no possible confusion there, because neither pole of the earth, so far as he knew, happened to be marked. The paper was one of extreme interest, for although many people had some sort of notion as to how these various errors were corrected in ships, very few comparatively knew exactly how the bars of iron and the permanent magnets were used, and how each error was corrected. He thought it was a pity that Mr. Bottomley adopted the word "variation" instead of the word "declination," which he thought was the better one, because as it varied from time to time, you would be led to the awkward expression of a variation of the variation. In speaking of the history of the thing, he had referred to the Chinese compass, which he thought would be in one respect the sort of thing for Captain Beall's model, as it had a very small needle, and he fancied that was really the difficulty with his first model; the needle should have been reduced to the same proportion as the model of the ship, and there would have been no difficulty by a mirror, or some magnifying arrangement, in following its motion. When a boy he had a Chinese compass which was a very curious article. The most interesting part was not the needle, which was only half-an-inch long, but the rest of the compass. It was a large wooden disc covered with a number of hieroglyphics, the meaning of which he did not understand, but from the amount of characters on it he should fancy they contained as much information as an encyclopædia.

Mr. LIGGINS said he remembered very well upwards of forty years ago having a conversation with two of the most eminent Fellows of the Royal Society, on the trials that the Astronomer Royal had been making on board the first iron steamer that ever came into the Thames, the *Rainbow*. In great ships generally of the ordinary class—not grand ocean steamers—he did not think there had been much alteration in the mode of compensating the errors of the compass, and unhappily these ships were the most numerous, and had contributed most to the loss of life by shipwreck. It had escaped his memory that the heeling over of a ship on one side should have an injurious effect on the compass, as had been described, and he would suggest that that possibly might be the reason why so many ships going from north to south, notably from the English Channel to the Straits of Gibraltar, made a mistake, and ran on the coasts of Spain and Portugal. It was always attributed either to an error of the compass or to an indraught of the tide.

Capt. PARFITT said there was a passage in the paper which should be borne in mind by ships' captains, and that was, that in all circumstances, however good a compass he might have, it was necessary that he should from time to time test its accuracy. If he did that, whether the ship heeled over or was upright, he would find out whether he was right or wrong. That was where the mistake had been made in not constantly and regularly testing the accuracy of the compass. As regards getting on shore on the coast of Spain going to Gibraltar, he did not think, in the instances which had come under his notice, the heeling had had anything to do with it, for they were all steamers on an upright keel, and he could not understand how the heeling could have affected it. Strong currents were known to exist there, and they were very mutable, setting sometimes in one direction, sometimes in the opposite, sometimes before a gale of wind came on, and sometimes after it had passed. The compass had very little to do with it; but what had to do with it was that if a captain did not make sufficient allowance for these abnormal differences which he might have to encounter, he would very often, when he got into thick weather, come to grief, compass or no compass.

Dr. HOPKINSON, F.R.S., said Mr. Siemens suggested that an effective preventative of the disturbance caused in the compass by a dynamo machine when a single wire only was used would be found in the screening action of the iron ships. He should be very sorry to rely on any such screening action, and the point of his objection might be easily illustrated in this way. If the electrical conductor were laid in the centre of a thick iron tube symmetrical all round, that tube would not have the slightest screening effect. That being so, it became apparent that you could in no way rely on the iron of a ship to screen the effect of the compass on the surface. On the one hand it might have a screening effect, but on the other hand it might not. There was great advantage from another point of view in using a double conductor. It was quite easy to arrange matters so that if the machinery were running you could detect if either the positive or the negative wire, by any accidental cause, were more or less in contact with the ship, and correct the error before any evil consequences could ensue. Everyone must have been interested in the account given of the compass, but some probably would be surprised that Mr. Bottomley had not given any account of the exceedingly beautiful method devised by Sir William Thomson some time ago, for correcting and discovering errors of the compass without taking astronomical observations. He showed that, even in a fog, and with the ship's compass as inaccurate and disturbed as possible, it was possible to correct the whole of the errors with the exception of the constant error which was the same on every course. He should like to know if that exceedingly beautiful and ingenious method was at all extensively used.

Mr. SIEMENS said he had only wished to point out that Mr. Bottomley had not taken into consideration the action of the iron; of course he was aware that a wire in a tube was not screened, but in point of fact the iron was distributed round the wires in a ship in quite an unsymmetrical manner, and therefore it had a screening effect.

The CHAIRMAN said they were much obliged to Mr. Bottomley for his exhaustive paper. If he had not brought forward anything new, he had brought recognised and trustworthy information together in a readable shape, which would be an immense advantage to the master mariners of the country. The Government had nothing to do with the compasses of the great body of merchant ships. It was true that in the case of emigrant ships Government officers looked after the compass, and also in steam-ships which carried passengers, but the great bulk of the mercantile marine had their compasses supplied probably by good makers. Those compasses were adjusted by gentlemen who had no sort of diploma or authoritative document of qualification whatever, like the master mariner had, and he had known cases in which the compass had not been properly placed. It was very important, this being the case, that the master mariners who had charge of the ships should know exactly how to deal with the compasses. With regard to the name of the north-pointing end of the needle, he should be very sorry to see any change in it. Everybody knew what it meant—that it was the end that pointed towards the north.

Mr. BOTTOMLEY, in reply, said the last paragraph had called forth more remarks than the remainder of the paper, and he would refer mainly to that. Mr. Siemens admitted that in one ship an error had been produced by the single wire system, but the case referred to at the end of the paper was another ship —not the *Bengal*. Only two cases had come under his notice since this question was raised in which the single wire system had been adopted. In both cases the current in the wires had produced an error of from two to three degrees. Even if the work of fitting the ship were arranged at first so that no effect is produced on the compass by the current, after some time other lights may be added, and the wires may be brought so near the compass that an error will be produced. On the whole, he thought it most important that the double wire system should be used in every case. Mr. Siemens had said that it is easier to insulate one wire than two properly. Now, as regards the effect on the compass, it does not matter whether the wire is well insulated or not, if the single wire is used. When it is known that an error of the compass may be produced by adopting one system, and will not be produced by another, it seems desirable that the latter should be adopted. The unfortunate compass has quite enough difficulties to contend with which cannot be avoided in an iron ship without adding any others. It had been said that the captain would know the error produced by the electric light, and could allow for it. But the effect on the compass depends on the amount of current flowing, which varies with the number of lights. If only half the current were passing, only half the error would be produced. The captain would therefore have to alter the allowance for the electric light according to the number of lights burning. With regard to the question of the screening effect of the iron, he had not mentioned it in the paper, but he had thought of it before. It is a difficult question to say what the effect would be in any particular case. In some cases the iron might act as a screen, and in other cases not. After what Dr. Hopkinson had said, it was not necessary for him to say more on this subject. In reply to Dr. Hopkinson's question about the correction of the compass without taking bearings, this system is continually being used by adjusters in London, on the Clyde, and other places; it is also very much used in France. It is quite successful and of great service in many cases where it would be impossible to get the compass adjusted without detaining the ship. Captain Beall would find that Mr. Rundell was mentioned in the paper, and also the work of the Liverpool Compass Committee in connection with the fitting of the soft iron bar. With regard to the question of names of the poles of a magnet, it was rather too late to go into it. The calling of the magnetic pole, situated in the Northern hemisphere, the South pole, is certainly very puzzling. The red and blue poles were purposely proposed, because they are distinctive without leading to confusion.

The CHAIRMAN proposed a vote of thanks to Mr. Bottomley, which was carried unanimously.

NINTH ORDINARY MEETING.

Wednesday, Feb. 3, 1886; Lord ALFRED S. CHURCHILL, Vice-President of the Society, in the chair.

The following candidates were proposed for election as members of the Society:—

Blades, Charles Mountain, Stanley Mount, Northwich, Cheshire.
Corry, John, J.P., Rosenheim, Park-hill-road, Croydon.
Plumbe, Rowland, 13, Fitzroy-square, W.
Thomason, Yeoville, 40, Bennett's-hill, Birmingham.

The following candidates were balloted for and duly elected members of the Society:—

Armstrong, Walter Young, Engineers' Offices, Great Western Railway, Paddington, W.
Catterson, Samuel Prince, 34, Great Dover street, S.E.
Evans, John Luther, 2, Tichborne-street, Edgware-road, W.
Parken, Augustus Henry, Astney-lodge, Bournemouth.

The paper read was—

ARTISTIC BRONZE CASTING.

BY GEORGE SIMONDS.

Few metallurgical operations have been more wrapped in mystery and shrouded in romance than artistic bronze casting. At the mere mention of this subject the imagination conjures up visions of Michel Angelo, in his grief and disappointment at the loss of a whole year's work by his failure in casting the statue of Julius II., at Bologna; of that equally wonderful genius, Leonardo da Vinci, devoting ten years to the construction of an equestrian statue, doomed to destruction even during his own lifetime; and, lastly, and perhaps chiefly, our thoughts turn to Benvenuto Cellini, who has left us so vivid a description of his own labours, his failures, and his triumphs in this difficult art. And as if the history, as he relates it, were not wonderful enough, modern authors, headed by that prince of romancers, Alexander Dumas, have so extended and exaggerated their original, that to those whose ideas of statue-founding are chiefly derived from such sources, the process appears almost like a miracle, and the founder a being endowed with superhuman powers.

Most persons in easy circumstances are owners of certain small bronze figures, with which they decorate their mantel-shelves or sideboards, and which satisfy to some extent their natural craving for sculptured form. Few persons, however, have any but the vaguest ideas as to the processes by which these are made. They would probably tell you that they were cast, but that would be the extent of their information.

Two or three years ago, I was modelling a study of a lion in the Lion-house at the Zoological-gardens, and although I, as far as possible, withdrew myself from public observation, yet I was frequently questioned by visitors as to the object of my work, and its final destination. I was often amused and surprised by conversations on this subject between visitors to the gardens. On one occasion a lady and gentleman entered into conversation with me whilst I was at my work, and after I had explained to them the object of my study, and had told them that the work would finally be cast, they, evidently thinking that they had taken up enough of my time, withdrew a little way, though still looking on, and curious to know more. I overheard something of their conversation, and the lady was evidently anxious to know how the casting was to be done. Her companion explained it to her much as follows:—"Oh! well, yes, you see, when they cast a thing in bronze, they melt the bronze, and—and pour it over it!—and then it's cast, you know." Of course this explanation did not prove quite satisfactory either to her to whom it was given or to him who gave it, and they discussed the subject at considerable length, but without coming to any conclusion that seemed satisfactory to either of them.

It was hardly the time or place for a lecture on statue-founding, so I did not join in their conversation; but I resolved that, should a suitable opportunity present itself, I would not fail to avail myself of it, and endeavour to remove some of the mystery with which this subject seems to be surrounded, being assured that it is to the true interest of art that these matters should be more generally understood. Such an opportunity has been kindly afforded me to-night, and it will be my endeavour to show you, as clearly and as briefly as I may, in what manner the work of artistic bronze casting is conducted.

This subject is so large, that to treat it thoroughly, in all its branches, would require a course of at least five or six lectures, whereas to-night I must endeavour to condense as much as possible, in order to bring it within the limit of time at our disposal. I shall, therefore, omit all historical preface, and refer to ancient examples merely as they may serve in the course of the evening to point a moral. I shall also give much time to the consideration of the waste wax process, as being chiefly suited for the production of autograph bronzes of cabinet size.

Before a work of art can be cast in bronze, it must, of course, be in existence in some other material, and it may not be altogether superfluous to describe briefly the various stages a statue must pass through before it can be introduced to the world as a bronze. The sculptor usually embodies his first idea in a sketch, not, however, in most cases on paper, but in wax or clay. A sculptor's sketch is simply a statuette, very roughly modelled, and usually not more than five or six inches high. Works of this size do not require any internal framing for their support, and therefore lend themselves readily to any changes of design, even of the most radical description.

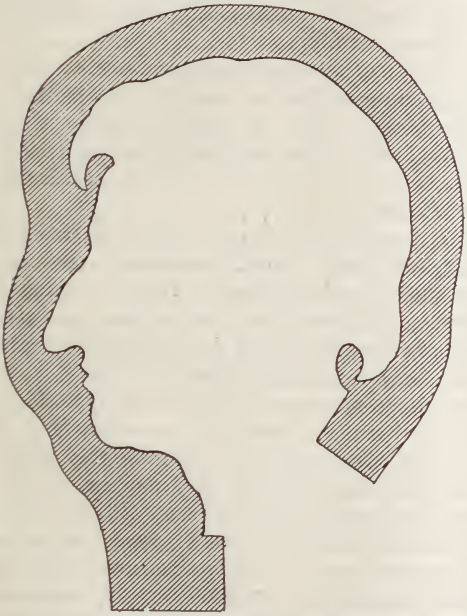
The attitude of the figure, the principle, masses of drapery, and, in short, the general arrangement of the composition having been decided on, the next step is the construction of a full-sized framing of iron, without which the statue in plastic clay or wax could not stand, but would yield to its own weight, and sink a shapeless lump to the floor. With the assistance of the iron framing, or skeleton, running through every part, it can be preserved for a sufficient time—often for several years—to permit the artist to bring it to that perfection of which he is capable. But even then it is not to be regarded as a complete work; for the plastic material, whatever it be, is certain to be destroyed by its very plasticity. Therefore, that it may be preserved, it must undergo a transformation which will render it hard and durable. If the statue has been modelled in a certain manner, and with specially prepared clay, the action of fire will produce this result, and then we call it terracotta—an excellent material for many purposes, but with which this evening we are not concerned. The only other method of preserving the model is to cast it. By this means, although the plastic model is destroyed, a *facsimile* is produced in another and more durable material.

Casting involves five processes, to wit—

1. The construction of the hollow mould.
2. The preparation of the fluid material.
3. The casting or pouring into the mould.
4. The solidification in the mould.
5. The liberation of the cast from the mould.

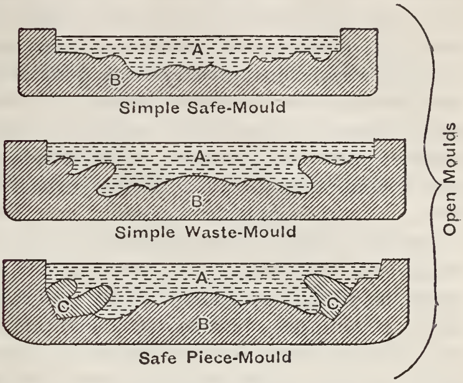
I must now, for a moment, beg your attention to the consideration of moulds. A mould is made over a piece of sculpture by the application of some soft material which has the property of rapidly becoming hard. By this means a concave impression is obtained, from which again, by a similar process, a convex *facsimile* of the original model may be produced. There are, however, many kinds of moulds used by artists, and it will be convenient here to give a short account of some of them. The sculptor roughly divides all moulds into simple and piece moulds. A simple mould is made all in one, without any loose parts, like a seal, or a pastrycook's jelly mould. A piece mould, on the contrary, is made of two or more parts, according to the requirements of the work. Moulds are also called open or closed moulds. An open mould is one of which one side only receives an impression. Simple moulds are, for instance, usually open moulds, so also are piece moulds of bas-reliefs or other flat objects. A close mould is almost always a piece mould, it may or may not be a safe mould. A safe mould is made up of many separate parts, so constructed as to be easily withdrawn from each other. These moulds can be used many times over without injury either to themselves or to the cast—hence their name "safe." A waste mould is made of one or of many pieces, but it can be used only once; it is destroyed or wasted in the process of casting. I wish you to remember particularly these last, the safe and the waste mould, because they are terms that I may have to use very frequently this evening. Moulds are made of very various materials, according to the objects for which they are constructed. Plaster is the most common, but wax and gelatine are also much used by artists. For bronze founding the foregoing materials are unavailable. The sculptor who would cast in bronze must use a material that will resist the intense heat of the liquid metal. Moulds for metal casting are made of sand and loam, of *luto* or *potée*, or, for small works, of compo. Of these we shall have much to say presently.

FIG. 1.



SIMPLE CLOSE WASTE MOULD.

FIG. 2.



A, The cast; B. The cope or case of mould; C, The loose pieces of mould.

Let us suppose then that an artist has completed a statue, and, having already cast it in plaster, wishes to reproduce it in bronze. How is he to set about it? If this work is of large dimensions, it is very unlikely that he will have suitable premises for the purpose, for although small works can be cast almost anywhere, no casting on a large scale can be reasonably undertaken unless a suitable foundry is available. Such a foundry should consist of a large and lofty room about 40 feet long by 24 feet wide, the larger indeed, the better. A row of small furnaces should be built along the wall at one end, and at the other end should be situated the reverberatory furnace for large work, whilst a very large portion of the floor should be occupied by the pit. The small furnaces before mentioned are draft furnaces of the ordinary type, and are made to take crucibles up to about 60 lbs. capacity. By pouring the contents of several crucibles together, castings of considerable size can be made, even with these small furnaces. Larger quantities than can be conveniently melted in the small furnaces must be treated in the reverberator, which is occasionally made of very great capacity. That which was used for the statue of Louis XIV., cast by Keller in the year 1699, contained no less than 83,752 lbs. of metal, which was run down and poured in 40 hours after the furnace was started.

The pit of which I have spoken is used to bury the moulds previously to casting. This is with a two-fold object; partly that the pressure of the earth outside the mould may enable it to resist the pressure of the metal from within; and also in order that the openings through which the metal is poured may be placed at a convenient level, which would not be the case if large moulds rested on the floor of the foundry.

Besides the large and small furnaces, and the pit which I have just mentioned, our artist would also require at least one blacksmith's forge and a powerful crane, not to mention drying stoves and pugging mills, and storerooms for various purposes. It is extremely unlikely, therefore, that many artists will be in possession of such premises and plant. It follows then that he must, as a rule, consign his larger works to one of the commercial foundries for execution. Nor is there any very great hardship in this. It is in such cases only requisite that the great lines and masses should be faithfully reproduced. Any delicacy of touch that might be put into such a work would be useless, because it could not be seen, and, therefore, would not be missed in the casting.

It occasionally does happen, however, that such premises as I have described are at the artists' disposal, and in this case, the best work is certainly expected of him. Such a case was that of my old master, the late Chevalier Louis Jéhotte, of Brussels, in whose studio and foundry I gained my first practical knowledge of artistic bronze work, more than twenty years ago. The foundry was such a one as I have described, and the work in hand was the casting of the equestrian monument to Charlemagne, which was subsequently erected at Liège.

Now there are two principles whereby artistic bronzes may be produced. The one is that known as piece moulding, and is identically the same as that employed in making castings for machinery, &c. Continental artists and founders call it *moulage à la Française*, it having been brought to great perfection in France, where, indeed, it is supposed to have had its origin.

The other process is that known as "Cera Perduta," or waste wax process. It is the most ancient of the two, and has been practised from time immemorial by the artists and artisans of Italy.

Both methods have been, and are, successfully employed for the production of works of the greatest size. M. Jéhotte, however, decided, and all my late experience convinces me he was right, in favour of the *moulage à la Française*.

It may be well here to state the reasons why an artist should sometimes prefer one method, and sometimes another. When a piece of sculpture is to be produced on a very large scale, it is usual for the artist to make not only a careful sketch, but also, if he has a proper regard for his own reputation, he will make a model of a convenient size, usually about life size; and on this model he will bestow all his skill and art; taking into account the distance at which the colossal work will have to be viewed, its height above the level of the spectator, the effect of the atmosphere in diminishing its apparent bulk, and in distorting its lines, the influence of any surrounding objects, and more especially the varying effects of light and shade. When this model has been carefully completed, the work is then to be reproduced in all its details on the large scale. One pair of hands will not suffice for the production of so large a work, and several assistants are usually employed, under the supervision and control of the master, who, working with them, is thus able to produce what is practically an exact enlargement of his smaller model.

Works on a colossal scale cannot be produced by the eye alone, but must be the result of scientific procedure. The forms are so large that the workman cannot see the effect of what he is doing. If he has to descend from a scaffold ten or twelve feet high, and go perhaps fifty or sixty feet off, before he can get a comprehensive view, it is not likely that he will be able to correct any error which his eye may have discovered, because by the time he has again ascended the scaffold he can no longer recognise the exact spot that required alteration.

In these large works anything like individuality of touch is at a discount, surface modelling is practically useless, and artistic effect is alone realised by the rhythm of line, the harmony of proportion, by the skilful arrangement of masses of shadow, and by the true relation of each plane to the rest of the work. If this is achieved the result will be an artistic success, not to be enhanced by any amount of delicate manipulation, which would be entirely lost at the distance required for a comprehensive view of the work. It is, therefore, wise in the artist to select that method of casting which, while it faithfully reproduces these essential qualities, affords the least chance of mishap, and the greater facility for retrieving disaster.

The artist who enters on the production of a very colossal work is in the position of a general opening a campaign. He forms his plan, and lays down broadly the lines on which he intends to proceed; but he cannot foresee all the chances of war, nor the varying incidents which may oblige him to modify his plans if he would attain the reward of his labour.

Thus it is clear that for such works there is no system of founding so good as that which gives most scope to the founder, even if it were at the sacrifice of a very small degree of sharpness in the castings.

With regard to small works, however, the case is very different, and exactly in proportion as these are small does the importance of delicate touch and surface modelling increase, not that the other qualities I have just spoken of are diminished in value, for they are just as important as ever, but merely from the fact that the eye of the spectator is able to take in on the small scale that which it was unable to appreciate on the large. Many persons who are unaccustomed to look at sculpture intelligently, and who think that art means pictures alone, would be surprised to learn that there was any difference between the touch of one sculptor and the handling of another. For such persons a work is finished in proportion as its surface presents a polished uniformity. This idea is fostered by the miserable cabinet bronzes which are turned out wholesale by certain manufacturers, and are termed "art bronzes." These are often copies of fine originals, but most of their value is lost from the fact that they are cast in many pieces, which are then joined together, filed, and chased up in a happy-go-lucky commercial style by a not over skillful artisan. Thus every trace of the original hand is obliterated, all that remains is the design, and even with that liberties are often taken. The turn of a head, the movement of an arm, are often varied according to the convenience or ignorance of the fitter. Yet, such as they are, these *soi disant* "art" bronzes are replicated *ad nauseam*, and do duty as sculpture in the homes of the wealthy and well-to-do classes, who I venture, however, to predict, will, before many years are over, be as keenly alive to the merits of a bronze as they are already to those of a picture.

It will be an unspeakable comfort when these purely commercial productions shall be estimated at their proper value, and be relegated to the possession of those whose purses are too slender for the purchase of original works. These can only be produced by the wax process, and by the artist himself, or at least under his own immediate care and supervision. I propose now to explain to you, as clearly and briefly as I can, the method of casting statues in the ordinary way by piece moulding, or, as I told you it was called, *à la Française*. I shall then explain to you, as fully as time will permit, the other, or *cera perduta*, waste wax process, more especially in regard to its applicability to work of cabinet size.

The object of casting statues in bronze by piece moulding is to diminish the risk by facilitating the process. It is obviously easier to cast a part than the whole of a statue. This is the principle which underlies commercial castings. You will follow me more easily if I give you an illustration. I have chosen as the subject of this illustration one of my own works, modelled in Rome many years ago, and cast in bronze by one of the most celebrated founders in Paris, from a plaster cast which was carefully retouched by myself before it was delivered to the founder. You will perceive that the figure, which represents Divine Wisdom, stands on a tortoise surrounded by waves, and supported by a branch of coral. The first operation of the founder was to cut off the head and arms of the plaster model, and also the coral branch at its side. These were carefully replaced, being fitted with what are known in our profession as Roman or box joints. These joints, if properly made, ensure in the most effectual manner that the various parts shall not be misplaced in any degree whatever.

The plaster model thus became a compound of five separate parts, fitted accurately one to the other. This made the work of the founder much more easy and rapid. To mould and cast the head, the arms, and coral branch, each by itself, is so simple an operation that almost any lad in the foundry could be entrusted with it; but to cast the statue all in one piece would have entailed some rather complicated piece moulding. When denuded of its head, arms, and coral branch, the trunk is also a comparatively simple object to mould. I say comparatively, because there is in the folds of the drapery a great deal of piece moulding which requires care and skill. I cannot here go into every detail of the process, which, however, was briefly as follows:—The trunk of the figure was laid in an iron box or flask of suitable size, and loosely packed in with the loam used by bronze-founders. The figure being only about half imbedded in this loam, the surface of which is carefully pressed and smoothed all around the model, so that the latter presents somewhat the appearance of a *bas-relief*. The loam background, as I may call it, is then lightly and evenly powdered over with parting-dust, lycopodium being much used for this purpose on the Continent. The object of this is to prevent one portion of the mould from adhering to another.

The moulder then proceeds to work on the projecting portions of the model, making separate pieces, so that they can be withdrawn and replaced at will. When he has made as many pieces as his judgment tells him are requisite, he places another iron box or flask upon the first, and having applied the parting dust to the work, he makes of the same loam the cope or case which is to retain all the pieces of the mould in position, and which is itself held together by the flask, which is merely an open iron frame. The two flasks are then turned over, and the first flask, with its loosely packed loam, having been removed, the freshly exposed side is moulded in the same manner as the former, and the cope or case formed as before. The two flasks can now be separated, and the pieces of the mould removed one by one from the figure, and accurately replaced in the mould. This gives a correct imprint of the plaster model. If the metal were cast into this it would be quite solid, therefore it must be cored. The core is made by filling the cavity of the mould with the same loam, so that the figure is again reproduced. As, however, this loam figure occupied the entire cavity of the mould, it must be pared down, so that an empty space may remain between its surface and the interior of the mould. This space is that which will be occupied by the metal.

Of course such a core has to be supported by an internal iron framework, the ends of which, projecting through the openings of the neck, the arms, and at the base, serve to keep it in position; without this it would of course fall to one or other side, and thus prevent the flow of the metal.

Openings must be provided in the mould for the admission of the metal, and for the escape of the air; but as we are rather considering principles, than matters of technical detail, I shall not trouble you with the description of these at present, merely remarking that the vents for the air need not be so carefully arranged in casting on this system as in casting by waste wax, because the loam is very porous, and the joints in the mould facilitate the escape of the gases. By this process the risk in casting a statue is reduced to a minimum; no small advantage where colossal work is concerned. Nevertheless, when the bronze is cleaned from the loam, it will be found to be covered with lines from the joints of the mould; it is also not unlikely to be covered with a sort of hard skin, composed of particles of sand, which have been vitrified by the intense heat. This skin and these lines have to be removed, and the various parts of the figures must be joined together. It is very frequently found necessary to go over the entire figure with the file and chasing tool, to bring the work to one tone, and in that case it is not possible for the statue to retain any claim to be considered an autograph work. There can remain on it no touch of the original artist, and the fact of his signing it, and even numbering and dating it, will not save it from being merely a more or less excellent copy, and not an original.

Of course, if a sculptor chose to do the chasing and fitting himself he could do so, but think of the waste of time, not to mention the fact that even then the work would probably lose something of its original freshness and spirit.

This system of piece moulding for bronze is admirable for commercial purposes, and for colossal work it is all that can be desired, but otherwise its value is small, and I do not hesitate to say that a statue executed by this method cannot be esteemed by anyone who understands sculpture at more than a fraction of the price of the same statue if cast by the waste-wax process.

It is this waste-wax process, so unimportant commercially, so all-important artistically, to which I am about to call your attention. It is by this method alone that a sculptor can produce original bronzes in his own studio, without the drawbacks incidental to the former process of piece moulding.

Roughly speaking, this process is as follows:—The sculptor makes, of plastic wax, an exact model of the work which he desires to cast in bronze. This model must be hollow, the thickness of the wax being exactly that intended for the bronze. This wax model is to be moulded, both inside and outside. The mould must be all in one piece, and without seams. The wax, therefore, cannot be withdrawn without destruction either to itself or to the mould. But as the mould must be preserved till after the bronze is cast, the wax is withdrawn by melting it out. The bronze is then to be poured into the cavity.

Of course, this is not so simple as it sounds, and yet I hope to show that there is nothing in it that may not be successfully carried out by an artist in his own studio. I am speaking now exclusively of small works, that is to say, of works under life-size.

The first thing that claims our attention is the wax. This must be made harder for summer weather, and softer for winter use, unless, indeed, the artist is careful to keep his studio always at one temperature. This seems a small matter, but, nevertheless, it is of great importance, and much of one's comfort in working depends on it.

There are many different wax compositions, almost every founder having his favourite mixture. The chief ingredients, however, are beeswax and Venice turpentine. Some artists make use of no other ingredients and use no colouring matter. Most men, however, use in addition to the above, resin, lard, tallow, and pitch in varying quantities. I have made excellent wax either with or without these latter. Yellow wax is not easy to model in, it is therefore the general practice to stain it, in order to get rid of some of its transparency. In Italy, it is almost always coloured a brilliant red, with sulphide of mercury, which is entirely evaporated when the wax is melted out, and leaves no residue in the moulds. Almost any pure vegetable colour will do, or, indeed, any colour that will burn without leaving a residue; this is easily tested by placing a lump of the wax in a small white clay crucible, closing the top with a cover, to prevent any dirt getting in, and then burning away the wax. When the wax appears to have been consumed, you should gradually raise the temperature to a cherry-red heat, and then let it cool down. If, when the crucible is quite cool, you find it also quite clean, without any residue, you may be sure that your wax is good, and that the pigment used is perfectly safe.

Having, therefore, prepared the wax, and having satisfied himself that it is of the right quality, the artist will proceed to construct his model. He could make this at once in wax, and then cast it, but in event of a failure his work would be lost. As this is undesirable, he usually proceeds exactly as if the work were to be sent to a foundry, and having prepared his plaster model, he cuts it in pieces and moulds it in plaster, making safe moulds of each part. From these moulds the hollow wax models are produced. Of course, it is far better for the artist himself to re-touch these than that they should be so treated by any other person.

There are various ways of producing these wax models. Some artists cast them by pouring the melted wax into the mould, in which a core has been previously placed; others line out the mould by squeezing into it sheets of wax that have been prepared so that they easily take the required impress. Others, again, brush the liquid wax into the various parts of the mould, and having thus satisfied themselves that the surface is everywhere covered with a thin layer, they put the mould together, and fill it with melted wax, which, after a few seconds, is emptied out, leaving, however, an equal layer adhering to the former coat. This operation may be repeated as often as desirable; each time increases the thickness of the wax, and consequently of the bronze. Making the wax casts sounds a simple matter, and yet it is almost the most difficult thing connected with the waste wax process.

In Italy, where this system is much practised, nearly every *formatore* can get out good casts, but here it is different, and the sculptor will probably have to train his moulder. It is merely knack and practice, and any intelligent moulder will soon get into the way of it.

It is not the extreme sharpness of the impression that seems to me so very important, though that of course counts for something; but I generally prefer to work my waxes entirely over, and instead of merely retouching, to finish the work in the wax. It is the inside of the wax cast that is very important, because it should have a proper thickness of wax in every part, no more and no less. It is safe, however, to have rather too heavy than too light a cast, as there is no vitreous skin formed by a thick casting, as is usually the case when the piece mould system is employed.

The various parts which compose the figure having been prepared in wax, it is the part of the artist to join them together, and finish the work in wax exactly as he wishes that it should appear in bronze. The wax, being hollow, must be moulded or cored on the inside.

If the work is a very small one, say eighteen inches high, he may finish the wax first, and then put a few wires through it at various points which serve to keep the core in place; he can then pour the liquid core into the wax model, which will be strong enough to resist the pressure during the few moments required for the material to solidify.

If, however, the work is much larger, the wax will not have strength to support its own weight, much less the internal pressure of the core. In such a case it is requisite that the core be cast before removing the wax model from its mould. The plaster safe mould must in this case be so constructed that it can receive and hold in place the irons which support the core and retain it in position. For this purpose holes must be made through the walls of the safe mould to permit the irons to project. They must afterwards be held by the walls of the waste mould in which the bronze is to be cast.

The safe mould then, being lined to a proper thickness with wax, and having the core irons in position, is to be filled up with the liquid composition used for coring. The usual mixture is plaster and brickdust; some people use other ingredients, indeed I have a list of over five-and-twenty which have all been used for this purpose. The proportions used are very various, some persons recommending one-third brickdust and two-thirds plaster—and others three-fourths brickdust to one-fourth plaster. The truth is that these materials vary so much in their character that those proportions which are quite satisfactory in one locality are worthless in another. I believe, however, that it is best to use as little plaster as will suffice to bind the materials together.

The core, being surrounded by liquid bronze, is under conditions exactly opposite to those of the mould which contains the metal. The action of the metal is exerted to compress the core and to burst the mould. Moreover, its greatest bursting power is exerted whilst it is in a state of perfect fluidity, and on setting it contracts, relieving the pressure on the mould, and powerfully compressing the core. If the core is too hard and unyielding, it is certain to crack the bronze. It should be what is technically called "puffy"—that is to say, somewhat easily compressible; on the other hand, unless it has some ventilation to the outer air, it should not be too porous, or it will generate gas too rapidly by contact with the hot metal. In cores of considerable size it is always safest—indeed, necessary—to provide some means of escape for these gases by venting the core.

When such a vent or "lantern" is used, the core can be made more spongy, and consequently more readily yielding to the compression of the cooling metal. It is, however, a fact that, while modern practice amply justifies the use of a core-vent or lantern, the largest works cast by this method of which we have any historical record—such as the colossal equestrian statues of Louis XIV., by Girardon, Louis XV., by Bouchardon, and the Henri IV. on the Pont Neuf at Paris, by Lemot—were all successfully cast without any such precaution, nor can I find any mention of such a practice before the latter half of the present century.

The wax model with the core inside can be kept for an indefinite time, and thus the artist has ample opportunity to work on the wax, and bring it to as high a degree of perfection as his talents will permit. When, however, he desires to cast it, his first care must be the arrangement of the jets and vents. The jets are tubes destined to distribute the metal throughout the cavity of the mould, and the vents are other tubes which afford an exit to the air violently expanded and displaced by the molten bronze. The jets are comparatively unimportant, for the bronze, following the laws of fluids, will certainly fill every part of the mould, provided the air offers no obstacle to its progress.

It is, therefore, usual to have more vents than jets, and they should be so placed that wherever there is a bell or pocket formed by the configuration of the mould in which the air might be imprisoned, there must also be a vent provided for its escape. It may seem strange, but I believe it is a fact that greater attention is needed in this respect in small than in larger works, because in a large work the metal does not set so rapidly, and thus gives time for the air to escape into the pores of the mould, whilst the pressure to do so is much greater. In any case the labour of placing these jets and vents is but small, and as their importance is paramount, my advice always will be "When in doubt, put a vent—put a dozen rather than run even a small risk."

I said just now that the piece-moulding in loam did not require the same attention in this particular, as the joints in the mould acted as a complete network of vents. This would seem a very great advantage over the wax process, and so it would be were it not that the method of placing these jets and vents is so easy and simple that it involves but little skill, and is easily done by an assistant. The artist need not lose his time over it, beyond defining their positions and relative sizes.

The jets and vents, being merely a system of tubes leading from the outside of the mould to its inner cavity, become of course filled with metal, which remains as solid rods attached at one end, while the other end is free in the air. All that is therefore needed is to make rods of wax of the required size, and attaching them by one end in their proper position on the surface of the work, bend them into the required curves. As, however, it would be inconvenient to pour through more than one jet, it is usual to join them together in groups, and to bring these again together to one main jet, which leads directly from the basin, or "sow," into which the bronze is poured. By this means, the bronze flows from the main jet through all the subsidiary ones to the different parts of the mould.

The vents are treated in exactly the same manner, except that they do not usually end in one main duct but in several, as may be most convenient, nor do they rise to the basin, but come to the open air at the top of the mould, outside of the space occupied by the pouring basin.

Besides the jets and vents there are other rods of wax which are called drains or spouts; these are placed on the lowest portion of the work, and lead through the thickness of the mould, but slanting a little downwards to the open air. Their object is to drain away the wax where it is melted out, after which they have to be securely stoppered up. In very small works drains are entirely omitted, and the mould is merely turned upside to allow the wax to run out.

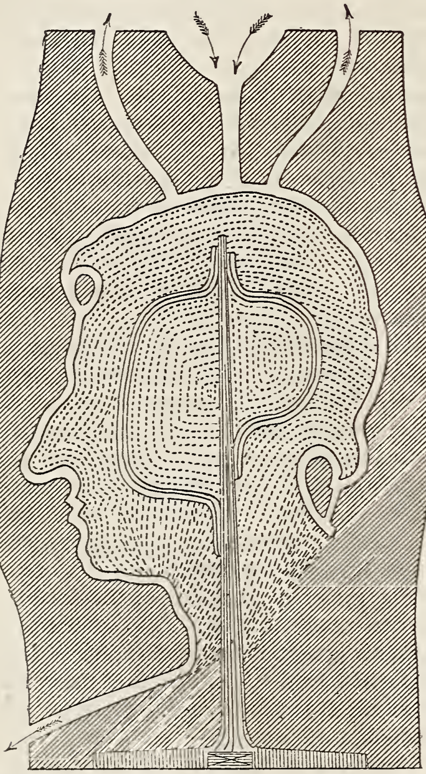
There are two principles of pouring bronze, each of which has its advocates. The one is the descending and the other the ascending principle. In the former the bronze is cast directly into the cavity from above, as shown on Fig. 3 (p. 254), which is not designed to rerpesent any particular work, but merely to illustrate a principle. By this method the bronze enters through all the various jets, and gradually fills the mould until it reaches the top. In the second or ascending principle, as shown on Fig. 4 (p. 254), the jets are taken right down to the bottom of the mould before they are allowed to enter its cavity. The metal of course rises to its own level, thus filling the mould from the bottom.

We do not know when the ascending principle was invented, we only know that it must of necessity be more recent than the direct descending method; but we do know that the ascending principle was employed by Michel Angelo for the second casting of his statue of Julius, and there is some reason to believe that Cellini employed it to cast his Perseus, but of this I am not certain.

The great monuments of Louis XV. at Bordeaux, and of Louis XIV. at Paris, were certainly cast on the descending principle, while Bouchardon cast Louis XV., and Falconet his Peter the Great, by the ascending method.

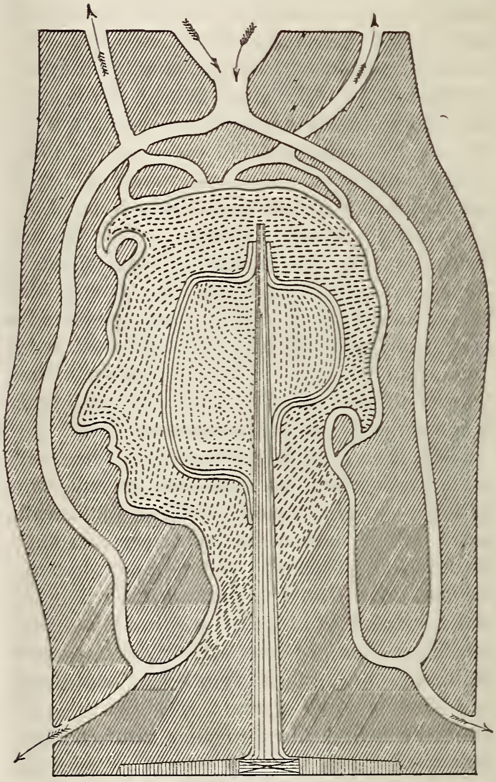
The disadvantages of the descending or direct method are these. When the bronze is cast it flows directly into the mould in numerous streams, which trickle over the core and over the surface of the mould, making a great amount of atmospheric disturbance in the cavity. These streams unite at the bottom, and then the mould begins to fill after the air contained in it has been heated and expanded to the utmost; nay, it is more than probable that portions of air caught between two metal streams may be dragged along and forced to escape by bubbling upwards through the molten metal, causing the latter to boil and work, and thereby endangering the delicate and frail inner surface of the mould. Moreover, the streams of metal, having united at the bottom, must rise and pass again over the surface of the mould before it can be completely filled. I do not know any objection to the ascending principle. There the streams of metal pass harmlessly to their lowest level before entering the cavity of the mould, thus its surface cannot be injured by the downward rush, and the air is not brought in contact with the metal until it begins to rise in the mould. No particle of air can become entrapped, for it is all above the surface of the rising bronze, with a free exit through all the vents above, through which it is forced by the pressure of the rising bronze, and by its own enormous expansion, which, however, cannot be so great or so sudden as when the metal enters from above. I should, therefore, recommend the artist always to cast his works on the ascending principle. The jets and vents having been arranged with due consideration, as I have described, it becomes necessary to think of the mould, and to consider the qualities to be sought for in a mould for bronze casting. In the first place, the material used must be one that is easy of application, and of a nature to resist the intense heat to which it must of necessity be subjected. It must also not be antagonistic to the metal, which would otherwise be spurted violently from the jets and vents, besides which it would certainly yield a blunt and bad impression.

Fig. 3.



Descending Process.

Fig. 4.



Ascending Process.

There are many recipes for such moulds extant; almost everyone who practises this art has his favourite mixture, concerning which much secrecy is observed.

There is, however, no great secret about this matter. Many of these moulds, especially those of large size, which, of course, have to endure the most heat, are made of *luto*, or *potée*, as it is indifferently called. This is nothing more than a mixture of which the basis is fine loam. The loam may be natural or artificial; the whole secret consists in purifying it sufficiently, and in grinding it very fine before use. The materials mixed with it are, fire-clay burnt and ground to an impalpable powder, emery, rotten-stone, hammerscale, &c., &c., the only object being to obtain a very fine and fire-resisting powder. Old crucibles powdered up are highly recommended by no less an authority than Cellini. Some material has also to be used that will bind this powder together. The celebrated founder, Jean Balthazar Keller, used white of egg and horse-dung. Cellini preferred rotten rags and cow-dung. The result sought for and attained in either case was the same. The body of the mould was composed of a very fine fire-resisting powder, held together by some other less refractory body, the result of which was that the mould, when tolerably dry, was firm and solid enough, but when exposed to a great heat it became very friable and porous. These moulds took a long time to make, but the operation was not one that required great skill on the part of the workmen employed.

This was the method of construction:—A sufficient quantity of the material having been prepared of the requisite degree of purity and firmness, a small quantity of it was placed in a mortar, and ground up until it became of the smoothness and consistency of oil paint. Armed with a soft bristle brush, and with a pot of this paint, if I may so call it, the assistant proceeded to give the work one complete coat—an even, thin coat, just as if he wished to colour it. This is allowed time to dry, when, if it has been laid on thinly and evenly, it will be found to have dried without a crack. A second coat is now laid on in the same way, and with the same care, as thinly as possible. This is again allowed to dry, and so on for about thirty coats. After the first five or six coats, however, a portion of cow-hair may be worked into the paint, and it may be spread a little thicker. After about thirty coats have been given, there will be a thickness of about three-quarters of an inch, and the mould may now be completed by building up in thicker layers until a sufficient strength is obtained. The mould must be hooped about in all directions with iron bands to strengthen it. After this, it being apparently pretty dry, a temporary kiln is to be built round it, and a gentle fire is kept up until the wax flows out through the drains before mentioned. A considerable quantity of wax will be lost, but some of it may be saved by placing tubes at the drains to lead it outside the kiln. This operation is usually, but not invariably, conducted in the pit beneath where the metal is to be melted.

When the wax has ceased to run, the fire must be let out, and the kiln taken down, in order that the drains may be stopped. These must be plugged with great care with the same material used for the mould; the kiln is then built up again, and the firing carried on as before, until the wax has been completely dissipated. When there seems to be no trace of wax left, the fire must be still kept up, and indeed urged on, until the mould and core are both of a fine cherry red, after which the fire may be let out, and the whole allowed to cool slowly down. If the mould is at the right heat, it can be seen on looking down the openings of the vents and jets, or on putting a piece of tarred rope down, when it will take fire if the heat is right.

The kiln being cool enough, it must be pulled down, and the pit must be filled up with fine dry earth, pressed firmly and evenly all round the mould, so that the top alone, showing the openings of the jets and vents, is visible above the ground. Be the work small or large, this process of firing is exactly the same, only that a mould for a very small figure can be fired in about eight hours, and the statue of Louis XV. took five weeks.

For small works, however, it is not advisable to use a *luto* mould. Compo is quite good enough. By compo I mean any mixture of which plaster and brickdust are the chief components. Many founders use for the moulds exactly the same composition that they use for the core, and it saves trouble to do so. It is better practice, however, to use a somewhat stronger compo for the mould. Some persons make an inner skin to their moulds of a closer and harder composition than they use for the backing up, and this is in accordance with theory and good practice. It requires care, however, as, unless the heat is carefully regulated, these layers sometimes separate in the firing. We will suppose, however, that the work has been successfully fired, and is in the pit earthed up and ready to cast.

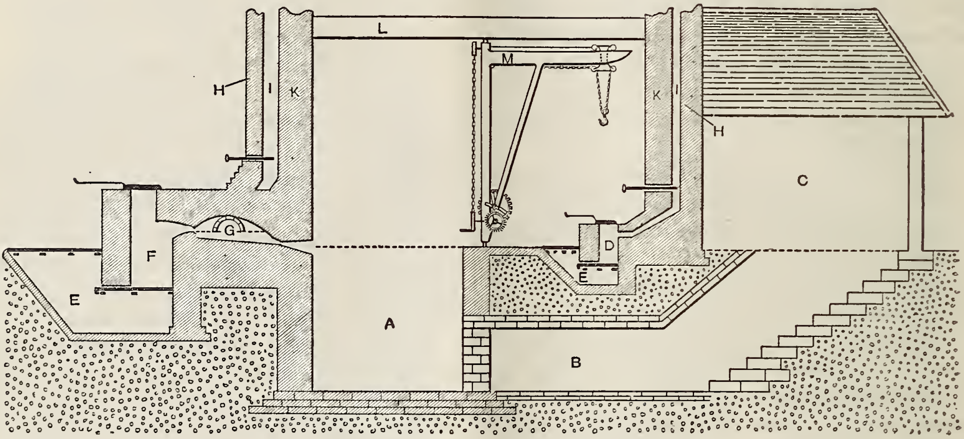
Our next consideration is the furnace. This may be made in many different forms. Only three, however, need be mentioned at present.

First in power and capacity is the reverberatory furnace, with its saucer-shaped hearth, and its flat-domed roof. It may be made of every varying size, but it is inconvenient when made for small charges. These furnaces are a very ancient invention, but until the end of last century they were made without any chimney, the draught being supplied through two or three long trenches, with the aid of wind-sails. Modern practice has dispensed with these last, and added a tall chimney, besides flattening the dome of the roof very considerably.

The furnace most suited for small works in the artists' studio is, however, the common air-furnace for crucibles. This furnace is cheap and easy to build, and takes up but little room. It is usual to build a row of them in the form of a low wall along one end of the workshop. The usual size takes a crucible with a charge of about 40 lbs. to 60 lbs. of metal; this is easily lifted out by one man. If more metal is required, several crucibles are poured at once. These furnaces are, however, sometimes made of much greater size, and crucibles are used which will take 1,000 lbs. of metal; but these, of course, are not likely to be used by artists very frequently.

Another kind of furnace which is very convenient is the portable furnace made by Messrs. Morgan, of Battersea. It is exactly suited for artists' occasional use, and will take a charge of 32 lbs., quite enough for a small bust, or a sketch, or statuette.

Fig. 5.



Imaginary Section of Statue Foundry.

A, pit; B, entrance to pit; C, shed or store over stairway; D, crucible furnace; E, ashpit with gratings; F, fire-box of reverberator; G, hearth of reverberator; H, chimneys; I, flues; K, wall of foundry; L, cross-beam; M, foundry crane.

The metal most suitable for artistic work is an alloy of copper and tin, either with or without the addition of zinc, lead, or both. The mixture used by the Kellers was, copper, 91·4; zinc, 5·53; tin, 1·7; lead, 1·37. Copper, 87·8; zinc, 6·52; tin, 5·1; lead, 0·58; gives also a very good metal, used for the Henri IV. Copper, 93, tin, 7 parts, gives an excellent bronze. An equal quantity of yellow brass mixed with this gives an excellent and easy-flowing metal. The bronze is usually considered to be improved in colour by using zinc, and lead is supposed to aid it greatly in flowing. The tin gives great hardness, and when the amount of tin used is over 20 per cent. the metal becomes useless for artistic purposes.

I am personally inclined to give the preference to a bronze composed of copper and tin alone, and 3 or 4 per cent. of tin gives an excellent and beautifully red metal. This alloy, however, when used in small quantities, is apt to prove rather sluggish, and requires more nice management as to the degree of heat than those alloys which contain a considerable amount of zinc or lead.

The operation of firing is a very simple one. And if the crucibles used are those known as the Salamander brand, there are no precautions to be observed. The crucible stand is placed on the bars at the bottom of the empty furnace. The height of this stand should be such as to bring the top of the crucible a couple of inches below the throat of the furnace. The stand should have a thin layer of ashes on it, to prevent the crucible sticking to it. Then put in as much metal as the crucible will contain, and cover it over with a proper cover; throw two or three shovels full of live coke into the furnace, and fill up all round your crucible with good clear broken coke up to the level of the crucible top. Place some large pieces of coke on top, taking care that they do not get in the throat of the furnace, and so choke the draught. Put on the cover of your furnace and draw out the damper, and fire as hard as you can until you find that the metal has run; then add more and more by degrees until you have a full charge, Some people keep a thick layer of charcoal dust on top of the metal, others do not take any precaution to prevent the formation of dross. Most persons, however, add a little borax, which powerfully cleanses the metal. It must be well skimmed off before pouring.

When the metal is ready to be withdrawn from the furnace, the coke must be cleared away from the pot, so as to make room for the crucible tongs. These are placed over the pot, and kept closed by a ring. The pot is then lifted vertically by one or by two men, and if it is a small one it is poured at once out of the tongs, but if it is a large one it is placed in a receptacle called a cradle, which is carried by two or more men. Sometimes it is poured into a hand ladle, or shank, and thence into the mould. This is not, however, usually done unless the contents of several crucibles is required, and then it is better to form a large basin, or core, at the top of the mould, the openings of the jets being closed with plugs. All the crucibles should be poured into this basin before drawing the plug; this ensures a clean casting, as all impurities float on the surface, and are not carried into the mould. When this basin is not used, it is of the utmost importance that the bronze should be thoroughly skimmed. If the metal runs down quietly, and rises up in the vents till it reaches the surface, it is a sure sign that the mould has filled properly. If, on the other hand, it makes much noise, and, worst of all, if it spurts and sputters in going down, and does not rise up again in the rents, it is certain that the casting is a failure.

The moulds for small—indeed for all—work should be broken down as soon as practicable after the metal has set, but great care must be used not to expose the surface of the casting too soon, for while it is red hot bronze is extremely fragile and liable to injury. The statue, on being freed from its mould, will be found with its system of jets and vents perfect as they were made in wax. These are then to be cut off with a saw as near as convenient to the surface of the statue. The figure is then to be well brushed with wire brushes, to remove all the particles of the mould; it is then placed in a bath of very dilute acid to pickle, as it is called. This cleans the surface of the metal very completely, and the artist can then repair any little defect that remains, as, for instance, the places where the jets have been and the like, after which it is usual to give the work its patina or colour.

It would be quite impossible for me to go into the subject of patinas this evening. It will suffice to say that the colour is produced by the action of various salts and acids on the surface of the bronze. A great variety of tints are obtainable, and in the selection of these every artist will, of course, exercise his own taste and judgment.

Although there are, both in England and abroad, excellent statue founders, whose work leaves nothing to be desired as far as the ordinary run of bronze work is concerned, and who are even able to go considerably beyond the average requirements of commercial sculpture, yet it has always seemed to me to be a matter of deep regret that autograph work in bronze is almost non-existent in England at the present time. Sculptors used, even in this country, to be their own bronze founders, and that at no very distant date. Chantrey cast his own works, and more than one sculptor's studio in London was arranged for casting statues of considerable size. The late Baron Marochetti was, I believe, the last sculptor who cast works in this country, although, only five or six years ago, a very nice statue foundry in the studio of the late Mr Weekes was pulled down and converted into livery stables.

If artists could be persuaded to become once more their own founders, as far, at least, as small works are concerned, I do not think that it would be a matter for regret even to the manufacturers of cabinet bronzes. These would still command a large sale, as the autograph works produced by artists would of necessity be higher in price and few in number I fear that it may be objected that bronze casting is not an artistic but a mechanical employment. Against this view of the case I must earnestly protest, as my own experience is that bronze casting requires quite as much artistic skill as marble carving, and that neither the one nor the other should be in other hands than the artist's own. Do not understand me as in any degree objecting to the employment of assistants in art, more especially in sculpture. I only protest against the practice of so important a process as bronze casting being left entirely in their hands.

It is, I fear, a great cause of reproach to modern sculptors that comparatively few of us are thoroughly and practically conversant with the various processes employed in our own profession.

It is no less a matter of regret that, in the various art educational establishments in this country, the student of sculpture is merely taught drawing and modelling, but is unable to learn the other processes whereby alone his modelled work can be rendered permanent. He is not only obliged to employ others to undertake this work, but he is absolutely unable to direct or to instruct them. He is, in short, at the mercy of his assistants until years of dearly-bought experience have enabled him to pick up for himself what is, after all, but the A, B, C of his profession, but which, unluckily for him, no school of art in in England teaches.

There is, perhaps, one remedy for this—namely, the possible establishment of studios in connection with our national art schools, where the student of sculpture could be practically taught the various processes incidental to his profession, such as piece and waste moulding, marble pointing, enlarging and reducing, carving, bronze casting, the erection and construction of colossal work, &c.

A year or two spent in such a studio in the study of practical sculpture would be invaluable to the student, and would enable English sculptors not only to instruct and guide their own workmen, but also, in course of time, to obtain competent English assistants, instead of being forced, as is at present too frequently the case, to employ foreign workmen. It would also enable artists to execute their own works in any material, and with their own hands whenever desirable.

I know that, for many years past, the English public has taken little or no interest in sculpture; but, unless I am mistaken, indications are not wanting to prove that there will, ere long, be a considerable change in this respect, and that sculptors will find it greatly to their own advantage to remember that they are artists, and not, as is too often the case, mere manufacturers.

In conclusion, let me once more insist on the inestimable value of autograph work, more especially for bronzes of small size. Unless these are really produced by the artist himself, and bear the palpable impress of his own mind and hand, unimpaired by foreign touch, and perfect throughout in character and individuality, I am really unable to see what value they can possess beyond that of a skilfully executed copy, nor can I admit their claims, in spite of date and signature, to be considered as genuine autograph works.

DISCUSSION.

Mr. **Liggins** said he had listened to this paper with a great deal of interest, and his mind went back to nearly forty years ago, when he had given him an exceedingly beautiful small casting in Berlin iron, but he was afraid iron casting was a lost art, for he did not see any such things now. In 1841, he visited a bronze foundry in Paris, where he purchased a beautiful statuette of Jeanne D'Arc, and was very much astonished to see the large number of pieces in which these things were cast, and at the exceedingly perfect manner in which the various parts were afterwards joined together. He should like to know how this was effected so as not to be perceptible, and also how the various colours of bronzes were obtained. Bronzes were exceedingly beautiful things to possess, and he was happy to say he had one or two fine Florentine specimens from the collection of Mr. Beckford at Fonthill, whose history he could trace for many years back.

Mr. **Watkiss Lloyd** said he was old enough to remember the statue of Canning being put up in Palace-yard, which was of a marvellously green colour. This gave rise to a *bon mot*, for when some one said that Canning was not nearly so big as that, the reply was—"Nor was he by any means so green." He should like to know how that exceptionally green colour was produced.

Mr. **Young** said he had had about twenty years' experience in bronze casting, but really the paper was so exhaustive that it was impossible to add anything to it. As had been said, it was much easier to cast colossal works in pieces. For instance, the lions in Trafalgar-square were in a great many pieces, and were fastened together with internal rivets. If closely examined, too, they were of different colours, though there was a general grey tint over the whole. He had the casting of the sphinxes, which were in two parts, but the composition of the metal was first decided upon, and then it was all melted at once so as to ensure the same tone throughout; it was about 89 copper and 11 tin, some of the latter no doubt evaporating in the melting process. Casting in bronze by the sand process took a considerable time. Those founders who undertook it for commercial purposes reproduced models supplied by sculptors, and it simplified the work very much to cut them up; but of course they more nearly approached a work of art when cast in one, and there were many statuettes in London which had been cast in a single piece. The description of the process must be very interesting to sculptors, and he should like to see it more generally carried out, and there would not be much difficulty if the lines Mr. Simonds had so clearly laid down were followed.

The CHAIRMAN, in proposing a vote of thanks to Mr. Simonds, said this was the first lesson he had received in bronze casting, and he was therefore not in a position to comment on the paper. The methods described of casting by the ascending and descending modes were very interesting. The natural process which would occur to an ordinary mind would be to fill the mould from the top, but as had been explained, there were certain difficulties in that, and it was obvious, on a little consideration, that the ascending method must be, for many articles, much the simplest and the more scientific. The wax process was an exceedingly interesting one, and for artistic purposes most valuable, as it enabled the whole figure to be cast in one piece, and this must certainly be a great advantage, notwithstanding the skill with which, when the object was cast in separate pieces, those pieces were joined together.

The vote of thanks having been passed unanimously,

Mr. SIMONDS, in reply to some further questions which were put, said it was necessary, in the wax process, that the mould should be hot, but it was not made hot on purpose; the bronze was poured in as soon as the mould was cool enough. In small castings, the hotter it was the better, so that it was not red-hot; in large castings it should be pretty cool, because the body of metal being so large, it heated the mould so much, that if it were too hot at first, it would produce sandburn on the surface. The joining of the pieces was done by the box-joints he had already described; a small rim of metal was left standing at the edge of each joint, and when the two were fitted together, these little rims were screwed or rivetted together, and then the metal was worked down with punches. Sometimes they were burned together. In order that the colour might be uniform, it was necessary, as Mr. Young had said, that when casting a subject in many parts the whole of the metal should be mixed at once, whether it were cast all at once or not, so that there might be no mistake about getting the same alloy each time. The little statue he had shown from Mr. Young's studio was a very fine specimen; there was very little chasing, and a great deal of the original surface about it. The joints were so well managed that, Mr. Young having forgotten where they were, it took them half-an-hour to discover them. With regard to the statuette of the lion, it was the first study for a very large lion he had been making for the memorial to the 66th Regiment, which was now being cast at Mr. Young's; and Mr. Liggins would be glad to hear that it was being cast in iron. It was considerably larger than those in Trafalgar-square. The green *patina* on the Canning statue was probably produced by sal ammoniac. The colouring was usually given by some acid or salt, sal ammoniac being generally used. The surface was scratchbrushed and cleaned off as perfectly as possible, to get off every particle of grease, and then a strong or weak solution, according to the colour desired, was stippled on with brushes; if the statue were warm, so much the better, as it made the evaporation quicker. Some *patinas* were produced by heat. It was a very complicated subject, and one on which very little was known, and consequently the results were various. There seemed no scientific accuracy about it. The Chinese and Japanese probably knew more about it than we did. In some cases, as in that of the small lion, for example, a small piece was cut out of the wax model for the introduction of the core, and was afterwards fitted on again. In larger works openings must be left to get the core out, as it was not desirable to leave it in. That was one reason why large statues should not be cast in one piece. One of the figures he had shown was a small replica of a colossal figure cast in wax in one piece at Pappi's in Florence, the height being 12 ft. 4 in. It was a very large and difficult work to cast in one piece, and was done simply as a *tour de force* to show what could be done in that way. In order to get the core irons out without injury, little boxes had to be made here and there, with lids, and these lids, instead of being put back into their places and closed up, were attached by little jets and vents of their own to the casting; then the core irons were got through the openings, and each little lid afterwards fitted into its place, and all those joints had to be closed up. It seemed to him that it was as just well to have the statue in several pieces fitted with a good box-joint.

Mr. ALEXANDER PAYNE said it would be extremely interesting to know if these elaborate methods were practiced by the Greeks and Romans, and also by the Japanese and Chinese.

Mr. SIMONDS said he knew the Japanese and Chinese cast by this process, but he could not say whether they knew anything about loam moulding. The ancients undoubtedly cast by the wax process. Most of the ancient works were cast in pieces, such as the horses at Venice, the Marcus Aurelius of the Capitol; and so was the bronze bull, formerly in the Capitol collection, which was a remarkably fine casting, but the pieces were fitted in rather a peculiar way. In addition to being screwed or rivetted together, after the edges of the joints were brought up, there were dovetailed dowels of bronze let in, to preclude, as it was hoped, any possibility of their being pulled out of place. In Naples also there was a very fine horse, also in pieces, and the celebrated little figures of the Narcissus and the Dancing Fawn in the Naples collection were cast in wax, but he could not say whether they were in one piece or not, as no one was allowed to touch them.

Mr. W. WARREN DE LA RUE asked if there was any objection to leaving the core inside?

Mr. SIMONDS said in a large statue it would add very much to the weight; besides which the core might absorb moisture and freeze, and cause cracks in the statue. He had noticed that in some bronzes at Venice where the core had been left in. In small articles there was no objection to leaving the core in, except the additional weight, which would not be great. In reply to further questions as to the proper thickness for the metal, Mr. Simonds said in large work the thinner the better, in small work it would be difficult to cast if they were made too thin. What was very thin for a large work would be very thick for a small one; and small works were generally much thicker in proportion than large ones. It was very difficult to get a uniform thickness throughout if the wax were very thin. He should call a casting no thicker than a penny very thin. A quarter inch was quite thick enough for the Wellington statue.

Mr. YOUNG said the thickness was governed by the surface over which the metal had to run. It would not do to be too thin, or the metal would chill before the whole surface was covered. In the Wellington monument the metal was about $\frac{3}{8}$ in.; in the Sphinxes $\frac{1}{2}$ in., because there was a greater surface for the metal to run over. In the Beaconsfield statue it was about $\frac{3}{8}$ in.; but in some portions $\frac{5}{8}$ in. Some portions of a statue might be almost solid, where there were folds in the drapery not large enough to get a core in properly; but it did not do to cast too many parts thick, or in cooling they would draw away from the thinner parts and break. Before undertaking such work, a man must thoroughly study the properties of the metal and the methods of founding, and from what Mr. Simonds had said, it was quite evident he must have had large experience, or he could not have described them so clearly.

Miscellaneous.

COLONIAL AND INDIAN EXHIBITION.

Mr. R. Murray Smith, C.M.G., executive commissioner for Victoria at the forthcoming Colonial Indian Exhibition, has been joined by Mr. James Thomson, secretary to the Royal Commission for that colony, who has just arrived direct from Melbourne. Mr. Thompson reports that excellent progress had been made with arrangements for the representation of the colony prior to his departure, the total number of exhibits forthcoming being estimated at 11,500. About a third of these are on board the P. and O. steamship *Kaisar-i-Hind*, expected to discharge cargo at once, and the balance will probably arrive during the present month. The Victorian Government has acted very liberally in the matter, having, in addition to guaranteeing a *pro ratâ* share of the fund for general purposes in the event of a loss being sustained, voted a sum of £10,000 for the preliminary expenses of the court. Many of the other colonial Governments have acted with similar liberality. All the accommodation in the steamers leaving Australia for London has been engaged for several months to come, and a large influx of colonists is expected.

COMMERCIAL MUSEUMS AT ANTWERP AND BRUSSELS.

The following memorandum is communicated by Mr. C. M. Kennedy, C.B.:—

Before proceeding to describe the Commercial Museums at Antwerp and Brussels, which we have recently visited by direction of the Foreign-office and the Board of Trade, it may be well to observe that there are two, or rather three, distinct types of museums already in existence; first, a museum of specimens of raw materials and manufactures imported from and exported to foreign countries, limiting the specimens of these exports to goods produced in countries other than that where the museum is established, so that information as to the description and price of goods used abroad is confined to what is produced by foreign competitors and does not disclose the prices, &c., of home competitors.

The second class of museums, or, perhaps rather export agencies, of which those at Lille, Stuttgart, and Munich are examples, are permanent exhibitions of articles produced in the country where they are established. Foreign buyers are invited to inspect these collections, and home manufacturers are strictly excluded. This limitation to *bonâ fide* foreigners must, however, often be eluded by stratagem, and there is also the difficulty that buyers in times of depression especially, will not come to the sellers, but will wait to have goods brought to them.

A third class of museums or export agencies intended to meet this state of things has lately been spoken of in Germany, viz., a ship fitted up as a warehouse, which is to take German goods to the principal trading centres of the world and force a market there.

To the same class belong the stationary collections of patterns which the Germans are reported to be establishing in North and South America.

The Commercial Museum at Antwerp belongs, however, to none of these types, being merely a collection of specimen articles of import and export arranged for the instruction of students at the

"Institut Superieur de Commerce" of Antwerp. This institution gives lectures, examines and grants diplomas to young men engaged in commerce. There are at present about 125 students in attendance.

The course takes two years, and the more general system of education adopted on the Continent, compared with our own, is well exemplified by it. In England, where trade is kept in well defined grooves, it would seem strange to see a young man in the wool trade attending lectures on mineral ores or tobacco, so as to have a wide, if rather superficial, knowledge of all branches of trade.

The Antwerp Exhibition, which has just closed, contained two special trade collections, namely, the Congo section, which was organised and supplied by the Brussels Commercial Museum, and the French colonial section, which showed specimens of the articles produced and used in all the French colonies. The town of Antwerp, too, had as an especial exhibit a very imposing triumphal arch, composed of specimens of Antwerp foreign trade; but this was, of course, rather for the general purpose of the Exhibition than for private use.

Coming now to the Commercial Museum at Brussels, we would wish, first, to record our thanks to the Department of the Affaires Etrangères, from whom we received every attention and facility in inspecting the building and its contents.

The museum is a large and fairly commodious structure, situate in the Rue des Augustins, not far from the Bourse, and within easy reach of both railway stations. Not having been built for its present purpose it is somewhat deficient in light on the ground floor, but it was secured at a low price in 1881 by the Belgian Government, who paid about £10,000 for its purchase and alterations; they also pay a rent of £420 a year to the town of Brussels. Furniture and fittings cost £3,000, and the annual amount voted by the Belgian Chambers for its maintenance is about £1,000.

The founders of the museum, which was started in 1881, had three chief objects in view: 1st, to show the Belgian importer and manufacturer where he could best supply himself with the materials for manufacture direct from the place of production; 2nd, that the manufacturer should have the best information as to the goods in use and demand in foreign countries, so as to enter the field of competition if he saw an opening; and 3rd, which is really a branch of the 2nd, that the manufacturer should also see the method of packing and getting up goods for export which is in favour in various countries.

The classification of the specimens is by 44 general groups, which are divided into about 400 classes, again sub-divided by the numbers of the specimens.

For instance, Group 25, "Products of spinning and weaving," is divided into 15 classes, which include some thousands of patterns, classed under the place where they are used. The explanation given in each instance further states the consul by whom furnished, the country where they are made, their cost and description, length and breadth by which sold, &c.

Each pattern has a number corresponding with that in the catalogue, and this publication contains particulars about all the chief articles, as to the quantity used in the country from which the specimens come and the proportion made there and elsewhere. The unprinted records of the department, which are shown readily to commercial applicants, give very complete details on these and cognate points of interest to them. The specimens are periodically furnished by Belgian consuls under a general order, which directs them to obtain patterns of all new articles of important consumption; and on application from manufacturers and persons interested, special demands are constantly made on the consuls for specimens to fill gaps in the collection. Duplicate patterns, when they can be spared, are also often given away to those interested.

Besides the collection of specimens, which occupies three floors of the museum, a reading-room is also available, where the chief commercial journals of all countries are to be found, as well as technical dictionaries and business directories.

A special office supplies all information as to freight charges by sea or land, no unimportant element of cost; another department collects and publishes notices of tenders required by all the Belgian public departments, and those notified by Belgian representations abroad. The commercial journals in the library also afford much information on this point.

No general notices of home and foreign bankruptcies appear to be published in connection with the museum; but Belgian consuls give special information to applicants as to the credit of persons in their districts, of course without a guarantee. The names of the chief houses interested in the trade, of which specimens are exhibited, are also among the particulars furnished to applicants.

The prices of goods in the catalogue are stated to include customs duties at the various places; the collection of foreign tariffs open to the public is, however, not kept here, but at the Ministère des Affaires Etrangères. As, however, the *Moniteur Belge* has printed all the chief tariffs in full, and adds from time to time any changes, a perusal of that publication will usually suffice.

We have not yet mentioned the weekly bulletin of the museum. This publication acts as a supplement to the catalogue, which is only printed once a year, and is constantly changing by the addition of new specimens and the removal of others in which the trade has become obsolete. The bulletin also contains abstracts from home and foreign consular reports and trade journals, &c., and the notices of tenders to which we have referred. Its price is ½ fr. each number, or 12 fr. a year in Belgium, and 18 fr. abroad.

As to the extent to which the public make use of the museum it is somewhat difficult to judge. Visitors who simply walk through the rooms and inspect the specimens without making any inquiries at the bureau are not recorded in any way, but we were informed that about twenty persons per day consulted the archives of the museum for special information. We are also told by Mr. Consul-General Grattan that at Antwerp both merchants and manufacturers have expressed themselves as favourable to the principle of the museum, and desirous that something similar should be established at Antwerp, as a supplement to the present educational museum to which we have referred above. Antwerp is naturally anxious to continue the great progress she has made of late years, both as an *entrepôt* and as a manufacturing centre, and we find that her imports have increased in the last ten years from 1,800,000 tons to 2,800,000 tons, and her re-exports in transit have nearly doubled. Whether this will substantially affect the supremacy of London in the Colonial trade time will show, but to establish more intimate relations between the foreign producer of the raw material and the home consumer by means of the import department of the museum is regarded by the Antwerp people as an important consideration.

With regard to the general question of establishing commercial museums in this country, three chief points occur to us as necessary to be first settled, viz.: (1.) Are the commercial and manufacturing classes in need of these institutions? (2.) Should a single museum be established in London, or several provincial museums in the chief manufacturing towns? (3.) Should any help be given by the State, except in the way of supplying articles to our diplomatic and consular machinery?

As regards (1) and (2), we would call attention to an article that appeared in the *Manchester Guardian* on the 31st of July last in which the need for such institutions is strongly urged. Several letters have since appeared in the same paper showing considerable interest in the subject, which has also been mentioned in the *Economist* and other papers. The second report of the Royal Commissioners on Technical Instruction, Vol. 1, p. 353, gives some interesting details of the Museum of Textile Fabrics at Mulhouse, which is stated to have exercised a very beneficial influence on the industry of the locality. It is true that this museum combines the art element with the purely commercial influence which we have been considering at the Brussels Museum, and this is a very desirable combination, provided that museums for the different branches of industry could be established in the large manufacturing towns where they could be in close connection with the schools of design.

In France, where the Chambers of Commerce were consulted two years ago, the majority were in favour of provincial museums subsidised by the State, and this opinion is being acted on. There is, however, a department in the Ministère du Commerce at Paris, where specimens sent home by consuls may be inspected, and notices of anything special being received are published in the *Journal Officiel.*

There is also the Museum of Colonial Products, lately forming part of the Antwerp Exhibition, and this reminds us that in case it is thought desirable to employ our consuls to render the same assistance as is given in Belgium, provision may also have to be made for obtaining similar specimens from our colonies, where, of course, there are no British consuls. The same necessity exists for bringing the domestic producer and the distant consumer in the colonies into closer relation, as in the case of foreign countries. Our foreign competitors are on the look-out to secure these markets. It is probable that some of the exhibits in next year's Indian and Colonial Exhibition in London may be available for the formation of such a museum.

In conclusion, we would suggest that, having regard to the importance of the matter at the present time, it would be advisable to appoint a Departmental Committee, consisting of representatives of the Foreign, Colonial, and India Offices, the Treasury, and the Board of Trade, to obtain the views of the Chambers of Commerce, and of other associations and persons interested in foreign trade, as to the propriety of establishing a museum or museums of the kind we have described, and such committee should also advise her Majesty's Government as to the necessary details of establishment and expense.

C. M. KENNEDY.
A. E. BATEMAN.

November 3rd, 1885.

Correspondence.

MECHANICAL MOTORS FOR TRAMWAYS

Mr. A. H. Rowan writes with reference to the note on p. 227 in the last number of the *Journal,* "that Mr. W. Rowan, of Berlin, was awarded the gold medal for his tramway car, as well as a silver medal for his car designed for secondary railways."

MACHINERY IN MINES.

Mr. Isaac Shone, of 4, Westminster-chambers, writes as follows respecting the discussion on Mr. Davey's paper:—

The power that can be obtained from 1 cubic foot of air, compressed to 54 lbs. per square inch, or 7776 lbs. per square foot when worked without expansion would be $7776 \times \frac{1}{467} = 1665$ foot-lbs., and the useful effect, therefore, could have been

$$\frac{1665 \times 100}{3692 \cdot 4} = 45 \text{ per cent.}$$

If the construction of Mr. Davey's air compressors had been as perfect as his engines and pumps appear to have been, he ought to have had a useful effect of $\frac{45 \times 85 \cdot 62}{100} = 38 \cdot 51$ per cent. instead of the 14·27 per cent. actually obtained. This difference, therefore, can only be due to defective arrangements in the inlet and outlet valves, clearance spaces behind the compressing piston, and other mechanical defects, which can be overcome just as the defects in water pumps have been overcome in the manner Mr. Davey so interestingly describes in his paper.

Mr. Baldwin Latham, in discussing Mr. Davey's paper, committed himself to some extraordinary statements. He stated :—"In many towns air had been largely used in connection with drainage purposes, but it was clearly one of the most extravagant modes of transmitting power which could be used, whilst the same thing could be done by water at much less cost."

As it is due to my efforts that compressed "air has been largely used in connection with drainage purposes," I may be allowed to presume to demur to this sweeping denunciation of the plan which I have initiated. His hearers and readers, if they knew nothing of my plan of utilising compressed air, would naturally think it was identical with that which obtains in mines, whereas it is not. Mr. Davey merely recorded evidences of the use of compressed air in executive engines, the friction of which, speaking generally, may vary from 10 per cent. to 50 per cent. On my plan there is no executive engine to actuate. The air, though used without expansion in my pneumatic sewage ejector, acts directly on the surface of the sewage within it just as the air acts on the pistons of Mr. Davey's executive engines. The piston in my case is the sewage to be pumped or ejected, and the friction due to the act of expelling a charge of sewage out of the ejector is practically *nil*. The friction due to the delivery valves, and due to the velocity of the sewage through my rising main, would be the same as it would be if the sewage were pumped through it in the ordinary way, and not ejected by pneumatic pressure directly applied.

Mr. Latham stated before the British Association at Southport that I could not hope to get a greater efficiency than 20 per cent. upon my plan, and by way of proving that this statement was correct, he actually wrote to me to say that at Warrington I was using air compressed to 27 lbs. on the square inch above the atmosphere to eject the sewage 10 feet in height. As 27 lbs. on the square inch corresponds to a water column of 62 feet, Mr. Latham triumphantly divided this by 10, the actual lift, and got at the efficiency of my plan of ejecting sewage. Considering that I only want, on my plan, a pressure of air corresponding exactly to the lift, plus the friction, it is not difficult to see how ignorant Mr. Latham must have been at the time of the *modus operandi* of my system. As a scientific and practical matter of fact, the efficiency of my ejector system for a lift of 10 feet would be approximately 67·4 per cent., and shortly I shall be in a position to demonstrate the correctness of this statement through the instrumentality of works of sewerage which are now being constructed on my system.

Mr. Latham said he expected a useful effect by the employment of such hydraulic machinery as Mr. Davey had been describing, 4½ times greater than could be obtained from air-compressing machinery. Taking this assertion in connection with Mr. Davey's own statements, with regard to the economy of air-compressing machinery, it would appear that Mr. Latham expects to get a useful effect of 110 per cent. from Mr. Davey's hydraulic machinery. A result which might be obtained possibly if Mr. Latham could hit upon some improvements in Mr. Davey's hydraulic machinery partaking of the nature of *perpetuum mobile*. To explain this contemplated gain in motive power Mr. Latham told his hearers something very startling about the expansion of air when heated 260°. All other authorities agree about the fact that it takes 490° to double the volume of a given quantity of air at 32°, and 980° to expand it three times, so that Mr. Latham will have to make out a very strong case before he can prove his assertions. The generally accepted opinion is that air expands in proportion to its absolute temperature, whatever its pressure may be.

In conclusion, I would advise those who are really interested in the questions raised by Mr. Davey as to the relative efficiency of steam, air, and water as motive power, to procure a pamphlet which has just been issued by the engineers of a compressed air power company for Leeds. The engineers are gentlemen of well known scientific and practical attainments. I refer to Messrs. Arnold Lupton, C.E. and M.E., M.Inst.C.E., and John Sturgeon, M.I.M.E. This pamphlet will, I venture to say, put quite a different phase to that which Mr. Latham would put upon compressed air and water.

MEETINGS OF THE SOCIETY.

ORDINARY MEETINGS.

Wednesday evenings, at Eight o'clock :—

FEBRUARY 10.—"Mining Industry at the Buda-Pest Exhibition." By BENNETT H. BROUGH.

FEBRUARY 17.—"Some Points in Electrical Distribution." By Professor GEORGE FORBES.

FEBRUARY 24.—"The employment of Autographic Records in Testing Materials." By Prof. W. C. UNWIN.

FOREIGN AND COLONIAL SECTION.

Tuesday evenings, at Eight o'clock :—

FEBRUARY 16.—"Present state of the Colonial Possessions of Great Britain." By ROBERT JAMES

Mann, M.D., F.R.C.S. The Hon. Sir Saul Samuel, K.C.M.G., Agent-General for New South Wales, will preside.

March 2.—"Bechuanaland and Austral Africa." By John Mackenzie, late Deputy Commissioner of Bechuanaland.

Applied Chemistry and Physics Section.

Thursday evenings, at Eight o'clock:—

February 25.—"Photography and the Spectroscope in their Application to Chemical Analysis." By Professor W. N. Hartley, F.R.S.

Indian Section.

Friday evenings, at Eight o'clock:—

February 19.—"Historical and Recent Famines in India." By F. C. Danvers, Registrar and Superintendent of Records, India-office. J. M. Maclean, M.P., will preside.

Cantor Lectures.

The Second Course will be on "Friction." By Prof. H. S. Hele Shaw.

Lecture IV.—February 8.—The Methods of Reducing Friction.

MEETINGS FOR THE ENSUING WEEK.

Monday, Feb. 8...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. (Cantor Lectures.) Prof. H. S. Hele Shaw, "Friction." (Lecture IV.)

Surveyors, 12, Great George-street, S.W., 8 p.m. Mr. H. B. Hans Hamilton, "Rights of Foreshore."

Geographical, University of London, Burlington-gardens, W., 8½ p.m. Mr. James W. Wells, "A Sketch of the Physical Geography of Brazil."

Inventors' Institute, 27, Chancery-lane, W.C., 8 p.m. Mr. J. T. Mackie, "The Examination of the Patent Office of Provisional and Final Specifications."

Medical, 11, Chandos-street, W., 8½ p.m.

London Institution, Finsbury-circus, E.C., 5 p.m. Prof. E. Ray Lankester, "Charles Darwin and his Theory." (Lecture II.)

Tuesday, Feb. 9...Royal Institution, Albemarle-street, W., 3 p.m. Dr. R. Stuart Poole, "Naucratis—the Egyptian Sources of Greek Art." (Lecture IV.)

Medical and Chirurgical, 53, Berners-street, Oxford-street, W., 8½ p.m.

Civil Engineers, 25, Great George-street, S.W., 8 p.m. 1. Discussion on Mr. C. E. Stromeyer's paper, "The Injurious Effect of a Blue Heat on Steel and Iron." 2. Mr. L. F. Vernon-Harcourt, "The River Seine."

Photographic, 5A, Pall-mall East, S.W., 8 p.m. Annual Meeting.

Anthropological, 3, Hanover-square, W., 8½ p.m. 1. Mr. Horace Darwin, "Exhibition of Anthropometric Instruments made by the Cambridge Scientific Instrument Company." 2. Mr. Francis Galton, president, "Recent Designs for Anthropometric Instruments." 3. Prof. A. Macalister, "A Skull from an Ancient Burying Ground in Kamtschatka." 4. Dr. J. G. Garson, "The Cephalic Index."

Colonial Institute, St. James's Banqueting-hall, 69, Regent-street, W., 8 p.m. Mr. Charles Todd, "Telegraphic Enterprise in Australasia."

Wednesday, Feb. 10...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. Mr. George H. Brough, "Mining Industry at the Buda-Pest Exhibition."

Geological, Burlington-house, W., 8 p.m. 1. Mr. R. Kidston, "A new species of *Psilotites* from the Lanarkshire Coal-field." 2. Mr. W. Hill and Mr. A. J. Jukes-Browne, "The Melbourne Rock and the Zone of *Belemnitella plana*, from the Cambridge to the Chilton Hills." 3. Mr. W. Hill, "The Beds between the Upper and Lower Chalk of Dover, and their comparison with the Middle Chalk of Cambridgeshire."

Graphic, University College, W.C., 8 p.m.

Microscopical, King's College, W.C., 8 p.m. Annual Meeting. The Presidential Address by Rev. Dr. Dallinger.

Pharmaceutical, 17, Bloomsbury-square W.C., 8 p.m. 1. Mr. E. M. Holmes, "Tumbeki." 2. Mr. E. J. Eastes and Mr. W. H. Ince, "Analysis of Tumbeki." 3. Mr. W. H. Ince, "Modified Extraction of Apparatus."

Royal Literary Fund, 10, John-street, Adelphi, W.C., 3 p.m.

Royal Society of Literature, 4, St. Martin's-place, W.C., 8 p.m.

Civil and Mechanical Engineers, 7, Westminster-chambers, S.W., 7 p.m. Mr. C. A. Adam, "Railway Stations."

Thursday, Feb. 11...Royal, Burlington-house, W., 4½ p.m.

Antiquaries, Burlington-house, W., 8½ p.m.

London Institution, Finsbury-circus, E.C., 7 p.m. Mr. F. Galo, "Travelling from the Days of Elizabeth to the Present Time."

Royal Institution, Albemarle-street, W., 3 p.m. Prof. W. Chandler Roberts Austen, "Metals as affected by Small Quantities of Impurities." (Lecture III.)

Telegraphic Engineers and Electricians, 25, Great George-street, S.W., 8 p.m. Discussion on Prof. D. E. Hughes's paper, 'Self-Induction of an Electric Current in Relation to the Nature and Form of its Conductor."

Mathematical, 22, Albermarle-street, W., 8 p.m.

Friday, Feb. 12...United Service Institute, Whitehall-yard, 3 p.m. Major C. Arundel Barker, "Some Suggestions as to the better training of our Infantry."

Royal Institution, Albemarle-street, W., 8 p.m. Weekly Meeting, 9 p.m. Professor Osborne Reynolds, "Experiments showing Dilatancy, a property of Granular Material, possibly connected with Gravitation."

Astronomical, Burlington-house, W., 3 p.m. Annual Meeting.

Civil Engineers, 25, Great George-street, S.W., 8½ p.m. (Students' Meeting.) Mr. A. S. B. Oakley, "Gold-Mining in the Wynaad, Southern India."

Quekett Microscopical Club, University College, W.C., 8 p.m.

Clinical, 53, Berners-street, W., 8½ p.m.

New Shakspere, University College, W.C., 8 p.m. 1. Rev. W. A. Harrison, "William Herbert and Mary Fitton in connection with Shakspere's Sonnets." 2. Mr. P. Lillwood Round, "The Play of Pericles."

Saturday, Feb. 13 ... Royal Institution, Albemarle-street, W., 3 p.m. Prof. A. Geikie, "The History of Volcanic Action in the British Isles." (Lecture III.)

Physical Science Schools, South Kensington, S.W., 3 p.m. Annual General Meeting. Prof. U. S. Pickering, "Experimental Error in Calorimetrical Work;" and "Delicate Calorimetrical Thermometers."

Botanic, Inner Circle, Regent's-park, N.W., 3¾ p.m.

Journal of the Society of Arts.

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FRIDAY, FEBRUARY 12, 1886.

All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

NOTICES.

MUSICAL PITCH.

The Council having had under consideration the subject of the Society of Arts' Musical Pitch, referred the matter to a Committee, which has reported as follows:—

"The Committee are of opinion that the reasons which determined the decision of the Committee that in 1860 recommended the Pitch since known as the Society of Arts' Pitch ($C = 528$), have now lost their force; seeing that in 1860 the French Pitch ($A = 435$ or $C = 517{\cdot}3$) was only just established, and was under trial, so that there was no objection to the proposal of another Pitch in competition with it.

"The French Pitch has now been established for twenty-five years, and has been adopted in many other countries, including Germany, Belgium, Italy, and Austria, it having been formally adopted by the Government of the last-named country as recently as November last at the International Conference at Vienna.

"The Committee think it would be a pity to cause a schism for the sake of a few vibrations, and that the Society would do well to abandon the Pitch known as the Society of Arts' Pitch, and to make public announcement of the fact.

"They also recommend that the influence of the Society should be employed in furthering the adoption of the French Pitch."

At their last meeting, the Council decided to adopt the recommendations of the Committee, and to give up any attempt to ensure the adoption of the Pitch known as the Society of Arts' Pitch. The Council have adopted this course in the hope of clearing away what might otherwise be an obstacle to the adoption of a uniform Pitch.

CANTOR LECTURES.

On Monday last, the 8th inst., Professor H. S. Hele Shaw delivered the fourth and last lecture of his course on "Friction," which was devoted to the consideration of the methods of reducing friction. A vote of thanks to the lecturer was carried unanimously on the motion of the Chairman.

The lectures will be printed in the *Journal* during the summer recess.

Proceedings of the Society.

TENTH ORDINARY MEETING.

Wednesday, Feb. 10, 1886; Warington W. Smyth, M.A., F.R.S., in the chair.

The following candidates were proposed for election as members of the Society:—

Beadle, Charles, Belvedere, Kent.
Wheen, Francis, 21, Norfolk-square, W.
White, John Samuel, Clarence-house, East Cowes-park, Isle of Wight.

The following candidates were balloted for and duly elected members of the Society:—

Blagden, William George, 1, Fenchurch-avenue, E.C.
Blair, John, Elmslie, Kilmarnock.
Hudson, John G., 18, Aytoun-road, Glasgow.
Morice, Beaumont, LL.B., 2, Garden-court, Temple, E.C., and Treffiys, Erith, Kent.
Pogson, William Norman, Nungumbauhum, Madras.
Robinson, Walter, Forehill, Ely.
Short, John Young, 49, West Sunniside, Sunderland.
Smith, Fred Snow, Yeadon, near Leeds.
Trubshaw, Charles, Midland Railway Company, Derby.

The paper read was—

THE MINERAL RESOURCES OF HUNGARY, AS SHOWN AT THE BUDAPEST EXHIBITION.

By Bennett H. Brough,
Assoc. R.S.M., F.G.S., F.C.S.

On May 4th, 1885, was opened in London the International Inventions Exhibition, the latest of the long series of exhibitions held in England since 1851. On the same day the first national Hungarian Exhibition was opened at Budapest. On August 23rd, two soldiers were admitted with one ticket—the military paying only half-price—and were, greatly to their astonishment, immediately taken into custody by the director of the exhibition and the police, and, being conducted to the director's office, were presented with 100 lottery tickets, worth 100 florins, which gave each of the two men 50 chances of winning 100,000 florins, this gift having been reserved for the holder of the millionth ticket issued. Considering that Budapest lies out of the beaten track of tourists, and that no notice was taken of the exhibition by the inhabitants of the Austrian half of the Monarchy, the fact that a million persons visited the exhibition in 120 days is a proof of the attraction of the first national exhibition.

The necessity that every civilised country is under to keep pace with the progress made by the rest of the world, had, previous to 1885, induced the Hungarians to hold industrial exhibitions, though on a small scale, at various places in the kingdom. Small industrial exhibitions were held in 1872 at Kecskemêt, in 1876 at Szegedin, and in 1879 at Stuhlweissenburg. And, since the International Exhibition of 1851, Hungary has been represented, either independently or in conjunction with Austria, at most of the International Exhibitions; for example, at Paris in 1855, 1867, and 1878, at London in 1862, and at Vienna in 1873; thus showing the world the steady desire of the country for progress.

After the success of the Stuhlweissenburg industrial exhibition, there was a general wish expressed for an exhibition on a large scale, which should show the agricultural and mining resources of the country and the present state of science and art in Hungary—in short, for an essentially national exhibition. It was evident that such an exhibition could be held only in the rapidly growing capital, Budapest; and, the popular wish being supported by the Government, a Commission was appointed by the Minister of Agriculture, Trade, and Commerce, to organise it.

The town park *(városliget)*, the site chosen for the exhibition, was the most favourable imaginable, both on account of its natural beauties, and from the fact of its being easily accessible. The area covered by the exhibition was 358,800 square yards; of this space 79,194 square yards were built over. The number of exhibitors amounted to 8,601. The exhibits were divided into 32 groups:—1, agriculture; 2, vineyards and gardens; 3, live stock; 4, animal products; 5, forestry; 6, mining and metallurgy; 7, chemical industry; 8, food; 9, wine; 10, pottery; 11, iron industry; 12, wood; 13, leather; 14, paper; 15, textile fabrics; 16, clothes; 17, furniture; 18, jewellery; 19, photography and printing; 20, music; 21, scientific apparatus; 22, architecture; 23, vehicles; 24, machinery; 25, locomotion; 26, naval architecture; 27, volunteer equipments; 28, health; 29, house industry; 30, technical education; 31, public education; 32, art.

The awards were made by a grand jury consisting of 570 members. In order to simplify their work, and to avoid all petty jealousy, only one class of medal was awarded—the bronze medal with the inscription *Erdem jeléül* (award of merit); each medal being accompanied by a diploma. One hundred special diplomas of honour were also awarded. The office of juror, as a post of honour, being considered the highest award, the jurors were, of course, *hors de concours*. Special medals and diplomas were, however, awarded to them and to the staff.

It may be mentioned, by the way, that the transfer of season tickets and jurors' passes was successfully prevented by employing a novel form of ticket. These tickets were of leather; on one side the name of the holder was given, and on the other side was fastened his photograph, twice stamped by the exhibition authorities.

It has been questioned whether the exhibition could be called strictly national. The international portion was very small, and consisted only of machines and tools necessary for the manufacture of Hungarian articles of industry, and agricultural machines of new or improved construction. A special feature of the exhibition, too, was the Oriental Pavilion, in which Servia, Roumania, and Bulgaria were represented. This exhibit was of value as an incentive to commerce between Hungary and her eastern neighbours. Lastly, in a special pavilion, products were exhibited showing the resources of Bosnia and Herzegovina. These provinces are now under the protection of the Austro-Hungarian Monarchy, so the exhibit could hardly be considered out of place in a Hungarian exhibition.

It is, thus, evident that the Hungarian Exhibition of 1885 had a purely national character; the few subordinate international sections being absolutely necessary in the interest of the further development of Hungarian industry. The best evidence for the national character of the exhibition is the fact that the labels on almost all the exhibits were written in the Hungarian language only.

The exhibits relating to mining and metallurgy justly occupied a prominent position in the exhibition. When the vast value of mineral resources is considered, it becomes a matter of the utmost importance that their extent, variety, and character should be made known. The rich mineral resources of the country were fully shown, including those which await further development and promise to open up a lucrative field for foreign capital and adventure. Indeed, this field seems to be inexhaustible, for although Hungarian mining is so ancient as to have been carried on by the Romans, new deposits are still being constantly discovered.

All mineral deposits of technical value are the property of the Crown, and prospecting can only be undertaken with the permission of the mining authorities, whose duty it is to see that all mining operations are legally carried out. A number of the most valuable mines are worked by the State.

The objects exhibited in Group VI. (mining and metallurgy) were distributed through twelve buildings:—1, Hall for mining, metallurgy and geology, containing the exhibits of the private mines and works, and the collective exhibit of Hungarian mining and metallurgical products; 2, Croatian-Slavonian Pavilion; 3, Pavilion of the Rimamurány-Salgótarján Ironworks; 4, Pavilion of the Kronstadt Mining and Smelting Company; 5, the Pavilion of the Royal Hungarian Iron and Steelworks, at Diógyör; 6, Pavilion of the Hungarian Asphalt Company; 7, Pavilion of the Austro-Hungarian State Railway, exhibiting products from its mines and works in Lower Hungary; 8, Béla Zsigmondy's exhibit of appliances for deep boring; 9, Pavilion of the Archduke Albrecht, showing specimens from the Bindt mines, and from the Marienhütte Ironworks; 10, Pavilion of the Danube Steam Navigation Company, showing specimens from their collieries at Fünfkirchen, Szabolcs, Somogy, and Vasas; 11, Pavilion of the Royal Hungarian Finance Minister, with exhibits from the State mines and works; 12, Count Schönborn-Buchheim's exhibit from his mines and works.

The exhibit of the Royal Hungarian Geological Survey should first be mentioned. This consisted of eight series of geological maps, nine publications, and five collections of fossils, rocks, building stones, clays, &c. From the maps exhibited it was seen that the geological constitution of the Hungarian mountains is, as a rule, similar to that of the Alps; the basis being formed sometimes of granite and crystalline schists, and sometimes of mesozoic rocks, on which the Tertiary rocks abut. Palæozoic formations are represented only on a small scale, whilst the mesozoic rocks have a large development. Diluvial deposits fill up the great plain out of which the mountains rise.

With reference to mining, Hungary takes undoubtedly a prominent place among the countries of Europe. It possesses inexhaustible deposits of rock salt, iron ore, and coal, as well as rich metalliferous veins, which were extensively mined in ancient times. Of late years ordinary metal mining has been in a depressed state; but great progress has been made in the iron and coal industries.

The districts where metalliferous veins are worked are Schemnitz and Kremnitz, Upper Hungary, Nagybánya, Transylvania, and the Banat.

The gold and silver mines of Schemnitz occupy, with regard to age, extent, and production, the first place among the mining works of Hungary, and may be reckoned among the most celebrated mines of the world. The origin of these mines dates, according to tradition, back to the eighth century, and their existence in the eleventh century is proved by authentic documents. On account of the constant dissensions in the country, the working of the mines suffered considerably, and it is only since the 16th century that a regular management has prevailed. In 1690 these mines produced nearly 17,000 oz. of gold.

The Schemnitz district is particularly interesting on account of its complicated geological character, as well as the extreme age of its mines. These facts have called forth a considerable amount of literature on the subject, one of the earliest writers being J. B. Merin ("Churchill's Collection of Voyages and Travels," 1704, vol. iv., pp. 822—828), who describes a visit to the Schemnitz mines in 1615. His account, though giving an interesting picture of the state of mining at that date, can hardly be considered scientifically accurate, as he gives great prominence to the appearance in the mine of "demons in the shape of little negro boys." The latest contribution to our knowledge of Schemnitz is a new map of the district which has just been completed by the Hungarian Geological Survey, the first proof of which was shown at the exhibition. The map has been brought out under the direction of Professor J. Szabó, and is essentially of a mining character, the outcrops of the lodes and all abandoned mines being carefully shown. It is coloured according to the international scheme of colours. In addition to the field mapping, a great number of typical rock specimens were collected and examined microscopically; and the results obtained naturally throw considerable fresh light on the geological nature of the district. The lodes may be divided into two groups:—(1.) The Schemnitz group, in biotite-trachyte (formerly termed greenstone-trachyte); and (2) the Hodritsch group in normal biotite-orthoclase-trachyte (formerly known as syenite). The Schemnitz lodes course in a north-east south-west direction, parallel to one another, and dip 45° to 80° towards east. They are filled with decomposed trachyte, quartz, or calcspar, containing auriferous silver and lead ores, iron and copper sulphides, and zinc blende. The Spital lode is the richest. It has a thickness of 30 yards to 40 yards, and has been proved for a distance of 5 miles, and to a depth of 360 yards. In the northern portion of this lode, native gold, argentiferous and auriferous galena, and copper pyrites are found; whilst in the south-west portion, in the neighbourhood of Windschacht, the ores are principally silver.

The Hodritsch veins, the width of which varies from a few inches to several yards, contain principally silver ores; the lode-mass consisting of quartz, calcite, and fragments of the country rock.

In the Schemnitz district, the highest working is 2,950 feet, and the lowest 600 feet above the sea-level. The workings were begun by the old miners by means of shafts sunk in the outcrops of the veins; but as these became deeper, main adit-levels had continually to be driven at greater depths to drain them. The oldest main-adit is the Bieber adit, which was begun in the fourteenth century, 1,950 feet above the sea-level, and is now 9,400 yards long. The Heilige Dreifaltigkeit adit, begun in 1549, 1,800 feet above the sea-level, is now 15,300 yards long. The Kaiser Franz adit was begun in 1494 under the name of the Handel Hodritsch adit, 1,380 feet above sea-level, and is now 15½ miles long. The Kaiser Joseph II. adit, begun in 1782 at a height of 730 feet above sea-level, is now the deepest discharge for the Schemnitz mine waters. The total length of this adit is 11 miles.

The total length of levels driven on the lodes is 230 miles, but of this total only 90 miles can be used. For transporting the ores along the levels, there are employed 50,340 yards of iron rails, and 42,910 yards of wooden rails. On the iron rails, the ore is transported in 16-cwt. trucks drawn by horses or men. On the wooden rails, the Hungarian trucks *(Hunde)* are still in use. These *Hunde*, or dogs, were so called, according to Agricola,* on account of the barking noise made by the wheels. The truck has two large wheels and two small front wheels; the wheels being fastened to a beam passing under the centre of the base of the truck. The centre of gravity of the full truck is thus above the large wheels. A very slight pressure on the handle at the back of the truck is sufficient to raise the front wheels, at the same time the truck is propelled forwards along the wooden rails, so that it runs only on two wheels, but stands on four. Described by Agricola in the middle of the sixteenth century, these trucks have remained in use unaltered to the present time.

For winding in the shafts, there are in use 5 steam-engines with a total horse-power of 150, 2 hydraulic engines, 2 turbines, 3 water-wheels, and 7 horse-whims. The deepest shaft is the Amalia shaft, 1,770 feet deep. Nine shafts are provided with cages. For pumping, there are 3 steam-engines, and 1 hydraulic engine. The compressed air for working the rock-drills is provided by 5 air-compressors; and, in the mines, 20 rock-drills are in use. For dressing the ores, there are 1,134 heads of stamps, 1 pair of rolls, 293 percussion tables, 2 jigging machines, 6 stationary, and 6 revolving buddles. In the works of the district 2,500 men and 350 boys are employed; the average daily wages of the men being 1s. 6d., and of the boys 5d. In the year 1883, there was produced 2,800 tons of ore ready for smelting, and 50,000 tons of ore for stamping. From these were obtained 3,858 ozs. of gold, 138,245 ozs. of silver, 17 tons of copper, and 820 tons of lead. The ores are treated at the Schemnitz smelting works, and the auriferous silver obtained is further treated at the Kremnitz mint.

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* "Quoniam uerò cùm mouetur, sonu efficit, qui nonnullis uisus canum latratui similis, canem uocarunt." *De re metallica.* 1566. Lib. VI., p. 113.

The dressing works at Schemnitz were constructed by Rittinger, and are well arranged. The most recent innovation is a second stamping of the ore; all that does not pass through a ⅕ in. mesh being automatically treated again. At the Ribnik dressing floor, there is a battery of three American iron stamps, the weight of each being 900 lbs. Three of these stamps do as much work as twelve wooden ones. They are, however, not considered perfectly satisfactory; the continuous wooden stamps being preferred. The Salzburg, or Lower Hungarian percussion table, is also found to be better than the Rittinger continuous percussion table.

At Windschacht, near Schemnitz, there is a central mine surveying office (*Markscheiderei*), where the plans of the mines of the district are made and preserved. The surveys are made with far greater precision than is usual in this country or in Germany, and the plans contain much information of permanent value. This office showed at the exhibition an interesting collection of new forms of instruments, including the theodolite, invented by Professor Chrismár, provided with a stand which can be clamped across the level, allowing the mine trucks to pass underneath. A survey can thus be made without interfering with the ordinary work of a mine. There was also exhibited an interesting collection of plans showing Péch's new method of preparing mine plans.

To the Schemnitz district belongs that of Kremnitz, where a mass of trachyte, 3,600 yards long and 1,200 yards broad, is traversed throughout its entire length by a main lode 10 to 30 yards wide.

The Gömör-Zips ore mountains in Upper Hungary contain numerous lodes, and consist of granite, crystalline schist, red sandstone, and Triassic limestone, with melaphyre, serpentine, and gabbro. The latter is of special importance, as at Dobschau it contains rich nickel and cobalt ores. The lodes of these mountains occur, for the most part, in crystalline schist, more rarely in granite or gabbro. With reference to the ores occurring, the mountain chain may be divided into three groups:—1. Between Hernád and Göllnitz, with copper ores and spathic iron ore. 2. Between Göllnitz and the Sajó, with cobalt and nickel at Dobschau, and antimony and copper ores at Schmöllnitz. 3. The portion of the chain south of the Sajó, with brown hæmatite and spathic iron ore. In the Lower Tátra Mountains, at Herrengrund, the locality celebrated for aragonite and celestine crystals, irregular deposits of tetrahedrite and copper pyrites occur. Similar deposits occur at Libethen and Magurka. These are fully described by Mr. J. Arthur Phillips. ("Ore Deposits," 1884, p. 337.)

The centre of the Nagybánya mining district is the town of Nagybánya, where numerous lodes occur in the trachyte. These lodes, which have an average thickness of two yards, contain auriferous pyrites, native gold, ruby silver ore, native silver, galena, tetrahedrite, and antimony ore. Important lodes also occur at Felsöbánya and Kapnikbánya.

The oldest rock of the Transylvanian mining district is crystalline schist, above which is deposited mesozoic limestone and tertiary sandstone. Out of this burst various eruptive rocks, which are traversed by gold veins, containing gold, either free or associated with tellurium and sulphur. The most important mines of this district are at Offenbánya, Nagyág, Vöröspatak, and Zalathna; Vöröspatak yielding the largest amount of gold. The largest quantity of gold is found where the rock is of average grain, and where the vertical main lodes intersect the veins with slight dip. The gold occurs in veins four inches to two feet in width, in leaves, or in needles, or coarsely disseminated, and is mostly crystalline. The private mines divide the product into three classes:—(1.) Gold stuff, in which the gold may be seen with the naked eye. This is pounded in mortars, and the free gold extracted from the slime, and amalgamated; the slime being dissolved at the royal works at Zalathna. (2.) Best ore, in which invisible auriferous silver occurs mixed with tetrahedrite, galena, and iron pyrites. These ores, when sorted, are sent to the Zalathna works. (3.) Stamp ore, in which the proportion of auriferous silver in 100 tons varies from 6½ to 32 oz. These ores are stamped in a primitive manner, with stamps weighing 100 lbs. to 140 lbs.; the stamp-heads being composed of hard quartz blocks. The value of the auriferous silver annually produced in the Abrudbánya-Vöröspatek district amounts to one million florins.

At the Zalathna smelting works, the ores, essentially iron pyrites, are roasted; the sulphur fumes being utilised for the production of sulphuric acid. The roasted ores are then run for coarse metal in blast furnaces. The coarse metal is ground, and digested with dilute sulphuric acid; sulphuretted hydrogen being evolved. Sulphur is obtained from the sulphuretted hydrogen by the action of sulphurous anhydride and calcium chloride; from the clear solution iron vitriol is obtained by crystallisation. The residue, containing a little unaltered coarse metal and all the gold, silver, copper, and lead, is treated for lead. The argentiferous lead obtained is cupelled, and the auriferous silver obtained is sent to the Kremnitz mint. Tellurium is obtained from the rich Nagyág ores. by boiling with sulphuric acid, pouring the mass into water, and allowing it to become clear. On adding hydrochloric acid, there is formed insoluble silver chloride, and tellurium chloride, which remains in solution. On adding zinc to the solution, crude tellurium (90 per cent.) is formed. In order to obtain pure tellurium, sulphuric acid is passed for a long time through the hydrochloric acid solution; the tellurium being then precipitated. This process has been recently described by Beaugey ("Annales des Mines." 1884. Vol. vi., pp. 453-495).

In the Banat an important ore-belt extends from Moldova in a northerly direction for a distance of fifty miles. In this belt, various eruptive rocks, collectively known as *banatites*, occur in contact with the crystalline schist. At the contact of these rocks, are various ore deposits, which were, at one time, worked on a large scale. With the exception of the iron mines, very few are worked at the present time.

Notwithstanding the enormous abundance of precious metals in Hungary, metal mining continually declines here as in the rest of Europe, owing to the influence of the American and Australian production. The coal and iron industries, on the other hand, have rapidly increased.

Coal occurs in Hungary in the following formations:—In the Carboniferous formation, at Eibenthal and at Reschitza; in the Liassic formation at Doman-Reschitza, Steierdorf-Anina, Fünfkirchen, Berszászka, and Ujvár-Törcsvár in Transylvania. Brown coal occurs in the Cretaceous formation, at Ajka, Baród, and Ruszka; and at a number of localities in the Eocene, Oligocene, and Neogene formations. Altogether, 35 coal deposits are worked in Hungary in 23 counties.*

The rock salt deposits of Hungary are second to none in Europe, and are apparently inexhaustible; the most important being in the Máramaros and in Transylvania. To the former belong the Szlatina salt mines, where the extent of the deposit is still unknown. The bed is worked at 6 mines; the quantity of salt available being estimated at 18,000,000 tons. The quantity of salt available from the Rónaszék bed, which is also worked at 6 mines, is estimated at 22,000,000 tons. The Sugatag salt bed is at present worked at 3 mines; the quantity of salt available being estimated at 25,000,000 tons. In Transylvania, at Deésakna, the quantity available is estimated at 800,000,000 tons, that of the Torda deposit at 800,000,000 tons, the Maros-Ujvár deposit at 100,000,000 tons, and the Parajd deposit at 95,000,000 tons. In addition to these, there are salt beds in many other parts of Hungary. The system of working the salt deposits was well shown at the exhibition by a series of large models executed in rock salt. Fine samples of the salt were shown at the entrance to the pavilion of the Finance Minister; the doorway being built of massive blocks of salt representing the entrance to an adit level. On either side were large obelisks of rock salt.

Other economic minerals were well represented at the exhibition. These came from a great number of localities, and included fireclay, china-clay, pigments, hydraulic lime, quartz sand for glass manufacture, and building stones (limestone, dolomite, granite, trachyte, basalt, mica schist, phyllite, and sandstones). Hungary is also rich in precious stones. Opal is found at Vörösvágás. The largest precious opal hitherto found is from this locality. It is in the Vienna museum, and is valued at 2,000,000 florins.

The most important branch of industry in Hungary is undoubtedly that of iron. An exhaustive report has been recently published by A. von Kerpely (*Stahl und Eisen*, vol. v. pp. 574-634), on the iron industry of Hungary as shown at the Budapest Exhibition. An abstract of this report will appear in the forthcoming volume of the *Journal of the Iron and Steel Institute*.

With reference to the geological age of the iron ores, and the nature of the fuel, five distinct groups of iron-producing districts may be distinguished. Of these, Transylvania is the first. Here, the iron industry is in a very primitive state; but the enormous Gyalér-Teleker deposits worked by the Kronstadt

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* A Hungarian county, a territorial division of the country for adminstrative purposes, corresponds to an English one. The Latin name *Comitatus* is common to both. The identity, however, is disguised by the Germans who call an English county *Grafschaft*, a Hungarian country *Comitat*.

Company insure its speedy development. The iron mines and works of the valleys of the two Körös rivers, and of the district extending from the western boundary of the Máramaros to the Poprád valley, are still in a very low state of development. Although there are large deposits of ore, and abundance of good wood, iron is produced only on a very small scale and in a very primitive manner. The iron industry of the eastern portion of Hungary, the valleys of the Temes and Karas, is of the greatest importance. In this district are situated the celebrated mines and works of Anina and Reschitza. The iron industry of the district between the rivers Hernád, Sajó, and Gran, is also of great importance, both on account of its present large production and its future prospects.

The iron industry of Hungary has made enormous strides within the last twenty years. From the year 1864 to 1883, the production of pig-iron has increased 44 per cent. The increase in the output of coal has been still greater. From 1864 to 1883, the increase in output was 157 per cent., whilst the increase in value was 250 per cent. The value of the brown coal produced during the same period increased 400 per cent. At the time of the exhibition there were 52 blast furnaces active in Hungary, with a total output of 241,800 tons of pig-iron; the number of workmen employed amounting to 30,000. The Hungarian iron industry is in a prosperous condition, and in the interest of future development is worthy, from the political economist's point of view, of powerful support, since it effects an annual circulation of 34,000,000 florins. The present production of pig-iron is in direct proportion to the consumption, which in Hungary is 250,000 tons per annum, or 35 lbs. per head of population. In Austria, the annual consumption is 39 lbs. per head of population. If the consumption of iron may be taken as a measure of the state of culture, it is evident that this is practically the same in both halves of the Monarchy.

There are vast subterranean stores of petroleum in the sandstones of the Carpathians, which, however, await fuller technical knowledge and more skilled labour to be satisfactorily developed. The production of mineral oil in Hungary, in 1870, amounted to 320 tons. The production decreased year by year, and in 1883 no mineral oil was raised.

An interesting series of asphalt products was exhibited by the Hungarian Asphalt Company. The mines of the company are at Felsö-Derna in Bihar county; the crude asphalt occurring at a depth of a few yards beneath the surface. The annual production is 8,000 tons of crude asphalt, giving 1,000 tons of paving asphalt, 300 tons of bitumen, 100 tons of pure asphalt, 300 tons of mineral oil, and 60 tons of asphalt varnish.

The mining and metallurgical industries of Hungary are more important than is usually supposed. The official statistics mention 778 mines and works, several of which (*e.g.* the State Railway Steelworks and the Kronstadt works) may be classed with foreign works of the first rank. The total value of the production of the mines in 1883 was more than 32,000,000 florins. The Hungarian mining and metallurgical industries are, however, far from being as remunerative as might be expected with the amount of technical knowledge and capital now available, for the reason that most of the undertakings are on a small scale, and are worked with little outlay and few workmen. A profitable field is consequently open for western capital and technical skill.

The number of miners and smelters in Hungary in 1883 was 46,000. The area of mining concessions was 145,000 acres, of which quantity 20,500 acres belong to the State; 91,000 acres are worked for coal, 24,000 acres for gold, silver, and copper, and 22,200 acres for iron ore. The condition of the mining industry may be seen from the following statistics:—The length of the mine railways with iron rails was 762,765 yards; with wooden rails 443,785 yards. For winding machines there were 130 steam-engines, 176 water-wheels, and 81 horse-whims. The number of pumping-engines was 249, of which 69 were worked by steam, 77 by water, 8 by horses, and 95 by man power. The workmen's pay varies in the different mining districts, for men, from 6d. to 3s.; for women, 4d. to 1s. 6d; and for children, 3½d. to 1s. 8d., without board.

The production of metals in Hungary during the years 1864 to 1883 was, according to diagrams prepared for the exhibition by W. Bruimann, as shown in the Table on the next page.

It may safely be said that no Hungarian mining or metallurgical product was omitted from the National Exhibition. The exhibitors in most cases not only showed specimens of the ores, but rendered the exhibit more instructive by adding geographical and geological maps of the district, statistical tables, models of furnaces, photographs, and plans

PRODUCTION OF METALS IN HUNGARY.

Years.	Gold.	Silver.	Copper.	Lead.	Zinc.	Quicksilver.	Cobalt and Nickel.	Iron pyrites.	Forge pig iron.	Foundry pig iron.	Coal.	Brown coal.
	troy oz.	troy oz.	tons	tons	tons	tons	tons	tons	tons	tons	tons	tons
1864	57,227	842,330	2,250	1,550	130	33	620	3,500	108,000	8,300	350,000	250,000
1865	57,548	842,330	2,260	1,260	200	40	570	4,400	93,000	8,300	360,000	260,000
1866	52,404	858,400	2,180	1,250	380	55	430	4,400	98,000	9,000	400,000	280,000
1867	59,156	880,910	2,400	1,680	340	61	650	3,500	95,000	10,000	400,000	350,000
1868	54,012	868,050	2,050	1,150	330	45	530	3,500	101,000	11,900	490,000	450,000
1869	49,832	835,900	1,750	1,040	460	35	570	6,000	114,000	13,100	490,000	550,000
1870	47,582	655,860	1,190	1,050	430	25	440	6,000	113,000	11,900	550,000	600,000
1871	45,010	649,430	1,280	1,620	470	18	450	6,000	123,000	10,500	640,000	850,000
1872	46,296	556,195	1,180	1,670	560	15	380	4,400	138,000	10,300	650,000	950,000
1873	40,187	594,775	1,050	1,480	620	14	390	6,000	158,000	10,000	680,000	950,000
1874	41,473	562,625	950	1,470	630	13	250	12,500	157,000	10,200	620,000	780,000
1875	51,440	684,795	1,050	1,750	520	18	240	22,500	156,000	8,600	630,000	820,000
1876	61,085	729,800	1,040	2,240	560	22	50	32 500	117,000	10,200	640,000	880,000
1877	55,298	659,075	980	2,130	55	26	460	50,000	120,000	8,200	690,000	910,000
1878	58,191	626,925	1,030	1,890	450	25	160	47,500	130,000	10,400	690,000	910,000
1879	51,118	594,775	1,040	1,980	25	24	350	55,000	120,000	8,900	680,000	920,000
1880	51,440	559,410	850	1,700	550	18	160	53,000	133,000	11,400	800,000	1,020,000
1881	51,118	565,840	840	1,780	620	18	140	50,000	149,000	14,000	840,000	1,110,000
1882	54,976	533,690	680	1,680	610	16	180	57,500	161,000	13,900	800,000	1,260,000
1883	52,083	536,905	800	2,100	200	12	150	57,000	165,000	10,500	900,000	1,500,000

of the mines and works, and in many cases special monographs were prepared, several being written in the German language.

A very instructive exhibit was that of the Schemnitz School of Mines. This consisted of a number of mining and metallurgical models, and diagrams, and a collection of mine surveying instruments. This school of mines is the oldest in the world, having been founded in 1763 by the Queen Maria Theresa. In the year 1807, a school of forestry was added; the two institutions being combined in 1838 under the title of "Mining and Forestry Academy." Many changes have taken place since Professor Warington W. Smyth published his account ("Memoirs Geological Survey," 1846, p. 485) of the institution, and severely criticised the course of instruction adopted. The most radical alterations in the school of mines date from the formation of the Hungarian Government in 1867, when it was ordered that the lectures should be given in the Hungarian language. Since the year 1872, the language used for instruction at the academy has been exclusively Hungarian. In consequence of the imperfect organisation of the academy, the Hungarian Minister of Finance next called upon the Council to draw up a plan of study, which should meet the requirements of modern times. A scheme was drawn up by the present director, Professor S. Farbaky, and, having received the Government sanction, came into force in 1873. According to this scheme, the courses of instruction include divisions for (1) mining, (2) general metallurgy, (3) iron metallurgy, and (4) machine construction; each of these divisions being practically the same as at the London School of Mines. The number of students of the academy from its foundation, to the end of the academical year 1884-85, was 5,827; of whom 3,927 were students of the mining school, and 1,900 of the forestry school. For the last few years the forestry school has been attended by a much larger number of students than the mining school; the numbers for the present year being 287 forestry students, and 89 mining students; total 376.

The exhibits of some of the larger ironworks show that the iron industry of Hungary is as fully developed as that of her western neighbours. Among the great Hungarian works, the Reschitza ironworks deserve special mention, not only because of their size and the capital they represent, but also on account of their employment of the most recent appliances, and from the fact that they furnish the greater part of the supply of steel rails for the Hungarian railways. These works are the property of the Austro-Hungarian State Railway Company, who also possess works at Steierdorf-Anina and Oravicza in the Banat. The collieries owned by the company are at Reschitza, Szekul, Domán, and Steierdorf-Anina in Krassó county. The coal measures at Szekul consist of shale and sandstone of carboniferous age; whilst those at Domán and Anina consist of Liassic shale and sandstone. The Szekul coal measures contain four workable seams, varying in thickness from 2 feet to 2 yards. At Domán there are two workable seams of Liassic coal, which are known to extend for three miles. In Reschitza-Szekul, the coal is worked by two shafts, 830 feet and 550 feet deep respectively. For winding, pumping, and ventilation, there are three steam-engines with a total horse-power of 285. The production of coal in 1884 was 51,722 tons; the entire quantity being consumed in the ironworks. At the Reschitza-Domán collieries, for winding, pumping, and ventilation, there are six steam-engines with 342 total horse-power. The production, also consumed in the ironworks, was 59,400 tons in 1884. The Steierdorf-Anina coalfield forms an ellipse, the length of which is 5½ miles, and its breadth one mile, with a thickness of 300 yards. For winding, pumping, and ventilation, twenty-three steam-engines are employed, with 2,609 total horse-power. The production of coal in 1884 was 217,394 tons.

Pig-iron is produced in blast furnaces, which are worked at Reschitza and Anina with highly heated blast. The Whitwell stoves employed for this purpose are heated exclusively with blast furnace gases. Open hearth steel is produced in Siemens-Martin furnaces with producer gas. Wrought iron is produced by the puddling process. The puddling furnaces and re-heating furnaces have for many years been provided with step-grates for firing with small coal. At the present time, at the works, there are in operation six blast furnaces, six cupolas, eight reverberatory furnaces, four Siemens-Martin furnaces, twenty heating furnaces, twenty-five puddling furnaces, nine Whitwell stoves, four Bessemer converters, and 104 coke ovens; 157 motors are employed with a total horse-power of 8,547, and 336 working machines, including twelve blowing engines, fourteen rolls, and twenty-four steam hammers. The works produced in 1883—98,433 tons of iron ore, 42,896 tons of pig-iron, 6,162 tons of castings, 24,804 tons of rolled steel, and 15,085 tons rolled iron. The total number of *employés* was 13,683; the Reschitza works alone having 6,725.

In Reschitza, it has been observed, as in Germany and Austria, that the work done by the *employés* is both quantitatively and qualitatively less than that of English workmen, to such a degree that the difference is not compensated by the lower wages paid in Germany and Austria. The Reschitza workmen are partly Germans from the Schwabian colonies of the Banat, and partly Roumanians, who are wanting both in the traditional technical skill and bodily power of English workmen. In order to encourage the men to render themselves more efficient, a promise is given to each workman that when he has proved himself permanently useful he shall receive the necessary advances for building himself a house, worth 600 to 800 florins, in the neighbourhood of the works, according to a general design. The advances are paid back by deductions from the wages, and at the present time the greater portion of the workmen are in possession of houses of their own, the price of which has been completely paid back.

On account of the out-of-the-way situation of Reschitza in the south of Hungary, at a great distance from all large towns, the price of wood is still so low that it can advantageously be used as fuel. Two blast furnaces, yielding 50 tons of pig-iron daily, are fed with charcoal. By their side, in 1880, a large coke blast furnace was erected. This cost 750,000 florins, and gives 60 tons of pig-iron per 24 hours. The ores smelted are rich in iron (60 to 70 per cent.) and contain but 0·02 per cent. of phosphorus, so that the Bessemer steel made from the pig-iron contains but 0·03 to 0·05 per cent. of phosphorus. This freedom of the ores from phosphorus renders the application of the Thomas-Gilchrist process unnecessary. Three blast furnaces are scarcely sufficient to supply the Bessemer converters, which require repair only at long intervals; but the number of blast furnaces cannot be increased without driving a new adit in the colliery. If the company decide to do this, the Reschitza steelworks will be in a position to supply the entire consumption of steel rails throughout Hungary. The balance-sheet for 1883 shows that from their Hungarian works the company derived a clear profit of 3,000,000 florins; the original capital expended having been already paid back.

Encouraged by the success of the Reschitza works, in 1858 the works of the Kronstadt Company were founded. They now supply Roumania, Servia, and Bulgaria with commercial iron; and, judging from the richness of their coal and iron mines, seem destined to follow in the footsteps of the State Railway Company. The Kronstadt Company have works in Krassó county in the Banat, and in Hunyad county in Transylvania, and produce cast and wrought iron tools and machinery. The works produce annually 18,000 tons of pig-iron, 8,500 tons of rolled iron, 1,000 tons of hammered iron, 2,500 tons of castings, 800 tons of sheet-iron, and 100 tons of tools. At the present time 3,586 workmen are employed, with 119 officers. Outside the works 1,200 men are employed. From the fact that these works are, of all the Hungarian mines, the furthest south-east, the founders of the works were obliged to make the necessary roads, as well as to found and maintain the means of culture which elsewhere belong to public institutions. The company, therefore, employs seven priests (three Roman Catholic, one Protestant, and three Greek church), five doctors, and four pharmaceutical chemists, and supports six schools with thirteen masters, a sick club, a hospital, a co-operative supply store, and public baths.

Other important iron works with instructive exhibits were—the Rymamurány-Salgótarjan Ironworks, the largest in Upper Hungary, employing 4,500 workmen; and the works of Count E. Andrássy, in Upper Hungary, with seven blast furnaces, producing annually 22,500 tons of charcoal pig-iron.

Mention must also be made of the great Transylvanian wire rope tramway, a model of which was exhibited by T. Obach. It is the most important undertaking of its kind in existence, being 33,290 yards long, with a total fall of 2,926 feet, and crossing 60 mountain tops, and 62 valleys, 28 of which have a free span of 650 to 1,546 feet; the wire at one point being as much as 810 feet above the valley level. The wire tramway is employed to bring ore and charcoal to two charcoal blast furnaces, built in 1883, in Hunyad county. The charcoal is brought from forests on the Vadudobri Mountains. The tubs employed have a capacity of 17 cubic feet, and hold 240 lbs. of charcoal. The ores are brought from the Gyaler mines; the ore tubs holding 600 lbs. of ore. The wire tramway transports 100 tubs per hour, two-thirds being ore, and one-third charcoal. The fixed ropes on the coal line are 0·67 inch, and on the ore line 0·98 inch. The hauling ropes are 0·51 and 0·71 inch respectively; all being made of the best steel. The total cost of the installation was £46,500. It has been at work for ore since November, 1883, and for charcoal and ore since May, 1884, and is an imposing example of what may be done with wire tramways. It is difficult to understand why the wire tramway, the invention of an Englishman, C. Hodgson (patent spec. 1868, No. 2281, and 1872, No. 418), should not have been utilised to the same extent in this country as it has been throughout the Continent.

I am unwilling to close this review of the mining features of the Hungarian National Exhibition without mentioning the unbounded hospitality with which foreigners were received by the inhabitants of Budapest. I also found the authorities, both at the exhibition and in the mining districts, always willing to give any information, statistical or otherwise, that might be asked for.

It is impossible to foretell what will be the actual effect of the first national exhibition on the Hungarian people. But, judging from what exhibitions have done in our own country, it may safely be inferred that it will be beneficial. By means of their jealous patriotism and energetic character, the Hungarians have already done wonders, and the rapid progress of their capital, Budapest, is a sign of the advance the whole nation is making in the race for higher culture. The country is one of the richest in minerals in Europe, taking a place with reference to coal after Great Britain and Germany, and with reference to precious metals second only to Russia. Several of the mines are worked on a large scale in a scientific manner; but the majority are "poor men's mines," worked with small capital and few workmen. Fresh discoveries of mineral are constantly being made, and a greater development of the mining industry is therefore most desirable. The large and well arranged collection of mining and metallurgical products shown at the Budapest Exhibition consequently deserved attention, not only from the mining student, but also from the speculative capitalist.

DISCUSSION.

The CHAIRMAN said he had not visited Hungary of late years except for a very brief period, but he formerly was pretty well acquainted with it, both on the surface and underground. This paper was a very interesting one from many points of view. In the first place, those who remembered the great Exhibition of 1851, and the great impetus it gave to industry both here and on the Continent, through the comparison it afforded of the products of different countries would be interested to find that in the most remote part of cultivated Europe such a successful Exhibition had been held. To scientific men again, the working out of the geology of the country would be very interesting, and to those connected with mining, the statistics which had been brought forward; whilst capitalists and speculators had also much matter for consideration laid before them. Again, investigators of the habits and ways, of thought and action, of different nations would find in the constitution of Hungary, and in the various races which were mingled together in that country, a series of studies of great interest, especially considering that the political constitution of Hungary was very similar to our own, and dated back from the early part of mediæval times. That constitution had been upheld throughout the greatest difficulties for century after century, through the wonderfully persistent character of the Magyar people, in spite of enemies both foreign and domestic. Considering the difficulties caused by the Turkish and Tartar invasions for a series of centuries, and the difficulties in protecting themselves against the changes threatened by the German nation, and the difficulties in connection with the Slavs and Wallachs, or Roumanians, it was evident that some special characteristics of great interest must attach to the people who now bore the leading part in the country. In no country in Europe was an Englishman received with more unbounded and, at the same time, unpretending hospitality than by the Magyar people. A reference to the map would show that the central portion of Hungary was a plain champaign country, bounded on the north, east, and south by ranges of hills, gradually passing into mountains; and whilst the Hungarians proper occupied the greater part of this low country, the mountain ranges were inhabited principally by tribes of various Slavonic origin; on the northern side, particularly in the neighbourhood of the mines of Schemnitz and Kremnitz, most of the people were of Slavic nationality, most of whom were Protestants, having their own bishops and clergy; and they were extremely industrious and persevering, though poor. Further to the east again there were mining localities of a somewhat similar character to that of Schemnitz; and going to the south, after passing an intermediate tract inhabited by Wallachians and Servians, you come to the Croatians and Slavonians proper, who inhabited the lower hill country, which contained several descriptions of mines, although none of the precious metals. The distribution of the various populations was, in itself, a matter of great importance politically, and of considerable interest in view of the different arrangements under which the various nationalities managed to live together in peace and quietness. There had been, in early days, when there was more intolerance between different religions, great difficulties, and it was very much owing to the inherent virtues and courage of the Magyar people proper, that a state of things had been brought about, in which a very large portion of the population, notwithstanding their differences of origin, were combined together to look upon patriotism in a higher light than that of mere differences of parties. They seemed to feel that Hungary was a great country which had to be maintained with all its honour unimpaired, and the difficulties had, to a great extent, disappeared; though in some portions, owing to difficulties of language and religion, there might still be some difficulty in getting everything to run smoothly. Mr. Brough had brought together in one hour an amount of matter which it took him a year and a-half to gather in a much more imperfect manner, walking, riding, and driving about the country forty years ago. It was then much more difficult to get at many of these particulars, which Mr. Brough had been able to collect in his brief visit to the Exhibition. At the Schemnitz mines, through their increasing greatly in depth in the last century, certain inventions were brought into use at an early period which had contributed in a considerable degree to some improvements in engineering matters which had taken place even in this country. The *hunde* might probably be looked upon as the first introduction of rails, which, first in wood and then successively in cast and wrought iron and steel, had changed the face of the world by facilitating communication. These little wagons first required the use of rails, the first step in advance being a pin underneath the wagon to keep it on the lines. In the seventeenth century the lead mines in the north of England adopted the use of rails, at first made of wood, and these blossomed forth into the "Newcastle roads," as they were called, in which larger wagons at the surface were employed, also running at first on wooden rails, then they were covered with thin plates of iron ultimately developed in the way he had mentioned. It was curious to see both in Hungary and Prussia wagons of much the pattern as were represented in old works on mining in the middle of the sixteenth century. Another point of great interest to which Mr. Brough had not referred, was the introduction of hydraulic machinery, which had often been wrongly attributed to a totally different country, Chemnitz in Saxony being sometimes confounded with Schemnitz in Hungary. At the former place very good stockings were made, but they knew nothing of the minerals which had been worked at Schemnitz for centuries; and there some of the earliest applications of hydraulic science were made. In the year 1769, the Society of Arts gave a premium of fifty guineas to Mr. Westgarth for the invention of a water-pressure engine; but just twenty years before that a gentleman named Höll erected at the Leopold shaft a machine of this kind, for the purpose of pumping water from the bottom by the impulse of a high column of water, and the engine, with modifications and renewals, had remained in use down to the present day. He remembered some years ago passing a whole night with the manager of the machinery there in examining its working, and on coming to the surface at 2 or 3 o'clock in the morning it was so cold that his clothes, which had become saturated with water, were frozen as hard as a board. This water-pressure engine was worked for many years in the north of England lead mines, and was then, somewhat modified, worked on a still larger scale at the Alport mines in Derbyshire, where it drove very powerful pumping machinery, and Sir William Armstrong, so justly eminent with regard to hydraulic machinery, though he might probably have worked out the whole problem in his own mind, belonged to a part of the country where this water-pressure engine was well known. He had now introduced quite a new era in regard to the machinery employed in harbours and docks. Amongst other points of interest which the paper suggested was the immense increase in the production of brown coal, iron, and steel since 1851. At the time he visited Transylvania and Banat, the idea of working coal was quite a novelty, a few of the brown coal mines were worked, and a few in the lias formation in order to supply the steamers on the Danube, one of the first means of progress which the Hungarians had enjoyed. At that time, however, the quantity of coal produced was very small indeed, now it had become a considerable industry. This also indicated how the forests, which some years ago were almost impenetrable, were gradually disappearing. In certain districts, for instance, parts of the Carpathians, and in the eastern part of Transylvania, you might find what appeared to be virgin forests, where in fact the means of communication were not sufficient as yet to render the timber valuable, and the question arose whether in some of those districts iron and steel of a very high character could not be produced. The comparatively low rate of wages which had been mentioned might strike some people, but it was by no means a matter of surprise to those who knew the low prices at which provisions were sold in countries where communication was not very perfect. At the time when he was in the country the wages were far lower than those now mentioned. Though the low wages were sufficient in some districts to keep the people in tolerable comfort, there were others in which considerable poverty and hardship were experienced.

Dr. DUKA said that he had learned much more from the paper than he could have gathered from reading many books on the subject. Many of the localities mentioned were known to him as a young man; but it was now nearly forty years since he left his native country. Schemnitz and the district of Upper Hungary he had passed through in 1848-9, and Transylvania and Lower Hungary he also knew to a certain extent, though not geologically. Last summer he revisited his native country, and saw the beautiful Exhibition, and it was a great surprise to him to see what progress had been made in the interval. As to the character of his countrymen, to which the Chairman had borne such flattering testimony, he could only say that every Hungarian was deeply sensible of the kind and sympathetic feeling which he always noticed whenever he met an Englishman; Hungarians looked to England as the home of freedom and liberty, and after the struggles they had undergone for centuries, it really seemed as if those who called Hungary a little England of the east were, to a certain extent, accurate. The Hungarian constitution was granted in 1222 by King Andrew, while the English constitution dated from 1214. At that time there was no communication between the two countries, and hence it was somewhat curious that the Hungarians should have had the same love of freedom and tenacity of purpose when they had once gained a victory; that was, no doubt, one of the reasons why so much sympathy was shown them by Englishmen. He could also assure them that an Englishman was always welcome in Hungary, and on his own part and that of his countrymen he must again express his gratitude to Mr. Brough and to the Chairman for the very kind expressions they had used.

Mr. H. H. COLLINS said he had long had a desire to know more of Hungary, and was very glad to have had the opportunity of hearing this excellent paper. He was particularly struck by Mr. Brough's description of the nature of the mineral lodes, especially in Schemnitz, and how little they answered to the old definition of a fissure in the ground filled with mineral, and how much they resembled what were now so familiar in Cornwall, a band of rock, wholly mineralised for a considerable width. He noticed, too, that most of the gold was in the free state, and that explained a problem which exercised many minds from time to time, how such poor ores could be worked at a profit. It seemed that on an average £200,000 worth of gold was produced from these little mines with very old-fashioned appliances, and he believed many of them did not average more than 3 dwts. to the ton, yet they were worked at a profit, though mines in Venezuela yielding as many ounces to the ton could not pay their way. This was partly, no doubt, because Hungary was a cheap country and Venezuela a dear one, but also because in Hungary the gold was free, and could be easily extracted, while in Venezuala a good deal of it was mixed with other materials, could not be amalgamated, and so was lost in the tailings. He understood that the stamp heads were made of quartz, which seemed about the most unlikely and improper material for the purpose, and he would like to know if he were mistaken. He should also be glad if Mr. Brough could give any information as to the use of water-jacketed furnaces at Budapest for melting iron for casting purpose.

Mr. H. TRUEMAN WOOD said there were one or two suggestive points arising out of what Mr. Brough said about the Budapest Exhibition to which it might be worth while to call attention. In passing he might say that this was not the only Exhibition in connection with which Mr. Brough had rendered useful service, for he had acted as reporter to the Jury which dealt with the mineralogical portion of last year's Exhibition at South Kensington, where his work was exceedingly well done, and was of a very useful character. It appeared from the opening of the paper that the Budapest Exhibition was a national, not an international, one, and he thought if our last year's Exhibition had been more of that character, it would not have lost much in interest. There were certainly some foreign exhibits, notably that of the Waltham watch-making one from the United States, and the Delany multiplex telegraph system, which were valuable; but with the exception of one or two of the kind, he thought the Exhibition would have gained had the space devoted to foreign countries been given to English manufacturers. This year, indeed, the South Kensington Exhibition would really be of a national character, consisting as it would of the products of Greater Britain. Again, with regard to the principal exhibitors being appointed jurors, and their deeming it such a high honour to be selected that they did not seek to gain medals, the difficulty was that until the juries were constituted, he did not see how the selection was to be made. The appointment was generally a matter of some difficulty, because you could not always find competent people willing to devote their time to a thankless task for which they were sure to be abused. The plan of giving only one class of medal had been tried before, and it no doubt had some advantages. The notion of having a photograph of the owner on every season ticket was one which he should like to see adopted in this country, for it was pretty well known that all Exhibitions lost a good deal because people could not rid themselves of the notion that season tickets were intended for the use not only of the purchaser but of his friends. The proposal had been considered, but it had been thought that Englishmen were too independent, and would not take the necessary trouble; at any rate the authorities had never ventured to try the experiment.

Mr. T. R. CRAMPTON said the little truck which Mr. Brough had described and shown a model of was a great pet of his, and he did not know a more useful tool for conveying minerals. When he required something of the kind some years ago he thought over the matter, and it ended in his making first that kind of truck, with a little modification so that it could run on ordinary rails, on a flat surface, or on tram lines, and could turn round corners or angles, either on the rails or on the flat, without a turn-table or switch crossing. The truck was balanced on a pair of large wheels in the centre, and at each end was a somewhat smaller pair of flanged wheels. When these were dropped at either end on to the rails they kept the truck on the line, and by raising it on to the middle wheel only, it could be turned in any direction with the greatest ease.

Mr. LIGGINS said he had been in Venezuela, and could quite understand that the high rate of wages and cost of transport would prevent the gold mines there competing with those of Hungary.

Mr. PHILIP asked if Mr. Brough could give any more information as to the processes of amalgamation in Hungary, and whether electricity was at all used, and if so, if it was found advantageous.

Mr. BROUGH, in reply, said he feared the paper would be thought too statistical, but the figures he had given had not yet found their way into the English or German technical journals, and, therefore, he thought it desirable to put them on record. In addition to what had been said by the Chairman, he might mention that blasting, as a mining operation, was first introduced at Schemnitz. A modification of Höll's water-pressure pumping-engine was now in use in a mine at Königsberg, in an abandoned mine which had been re-opened. The increase in the output of brown and liassic coal was very great, and if a process could be discovered by which it could be well coked and rendered suitable for blasting furnaces, it would have an enormous influence on the progress of the industry. Several such processes had been proposed, but at present they were only in an experimental stage, and iron smelters were obliged to use 50 per cent. of brown coal and 50 per cent. of Moravian, which necessitated importation. He had not seen the quartz stamp heads in use, but he saw a description of the apparatus in a monograph published by the Transylvanian Mining Office, which interested him so much that he spoke to the engineer in charge, and he assured him that they answered tolerably well. He could not give any information about water-jacketed furnaces for iron founding; but there was a water-jacketed furnace at Schemnitz for copper smelting, of which they were very proud. It was a Pilz furnace with eight tuyeres, and worked remarkably well. He was sorry he could not give any information about the amalgamation process which Mr. Philip inquired about. Mr. Liveing was out there for some time working at the process for an English company, but he understood it was unsatisfactory, and it had not been employed by any Hungarian company; they still used the primitive process as used at Freiberg.

The CHAIRMAN then proposed a vote of thanks to Mr. Brough, which was carried unanimously.

CORRESPONDENCE.—Letters have been received from Mr. H. Davey, Mr. Baldwin Latham, and Capt. Douglas Galton, which will appear next week.

MEETINGS OF THE SOCIETY.

ORDINARY MEETINGS.

Wednesday evenings, at Eight o'clock :—

FEBRUARY 17.—" Some Points in Electrical Distribution." By Professor GEORGE FORBES.

FOREIGN AND COLONIAL SECTION.

Tuesday evenings, at Eight o'clock :—

FEBRUARY 16.—" Present state of the Colonial Possessions of Great Britain." By ROBERT JAMES MANN, M.D., F.R.C.S. The Hon. Sir SAUL SAMUEL, K.C.M.G., Agent-General for New South Wales, will preside.

INDIAN SECTION.

Friday evenings, at Eight o'clock :—

FEBRUARY 19.—" Historical and Recent Famines in India." By F. C. DANVERS, Registrar and Superintendent of Records, India-office. J. M. MACLEAN, M.P., will preside.

CANTOR LECTURES.

The Third Course will be on " Science Teaching " By PROF. F. GUTHRIE, F.R.S.

Lecture I.—February 15.—Science as an Element in Education.

MEETINGS FOR THE ENSUING WEEK.

MONDAY, FEB. 15...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. (Cantor Lectures.) Prof. F. Guthrie, F.R.S., " Science Teaching." (Lecture I.)

Imperial Federation League, Mansion-house, E.C., 3 p.m. Annual General Meeting.

British Architects, 9, Conduit-street, W., 8 p.m. Mr. Alexander Beazeley, " The Swedish Building Law."

Medical, 11, Chandos-street, W., 8½ p.m.

Asiatic, 22, Albemarle-street, W., 4 p.m.

Victoria Institute, 7, Adelphi-terrace, W.C., 8 p.m. 1. Professor Dabney, "Final Cause." 2. Rev. Canon Isaac Taylor, " The Hittite Monuments."

London Institution, Finsbury-circus, E.C., 5 p.m. Prof. E. Ray Lankester, " Charles Darwin and his Theory." (Lecture III.)

TUESDAY, FEB. 16...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. (Foreign and Colonial Section.) Dr. Robert James Mann, "The Present State of the Colonial Possessions of Great Britain."

Royal Institution, Albemarle-street, W., 3 p.m. Mr. C. T. Newton, " The Unexhibited Portion of the Greek and Roman Sculpture in the British Museum." (Lecture I.)

Civil Engineers, 25, Great George-street, S.W., 8 p.m. Mr. L. F. Vernon-Harcourt, " The River Seine."

Statistical, School of Mines, Jermyn-street, S.W., 7¾ p.m. Dr. William Ogle, " Suicides in England and Wales in Relation to Age, Sex, Season and Occupation."

Pathological, 53, Berners-street, Oxford-street, W., 8½ p.m.

Zoological, 11, Hanover-square, W., 8½ p.m. 1. Mr. L. Taczanowski, " Description of a new Asiatic Owl of the Genus *Ketupa*." 2. Mr. O. Thomas, " Remarks on the Variation of the Skull with Age in the Canadian Marten." 3. Mr. W. L. Sclater, " A new Madreporarian Coral from the British Seas, and its Anatomy."

WEDNESDAY, FEB. 17...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. Professor George Forbes, " Some Points in Electrical Distribution."

Meteorological, 25, Great George-street, S.W., 7 p.m. 1. Captain Henry Toynbee, " General Remarks on the Naming of Clouds." 2. Mr. Arthur W. Clayden, " The Thickness of Shower Clouds." 3. Mr. Arthur W. Clayden, " The Formation of Rain, Hail. and Snow." 4. Mr. William F. Stanley, " Three Years' Work by the 'Chrono-barometer and Chrono-thermometer,' 1882-84."

Archæological Association, 32, Sackville-street, W., 8 p.m 1. Mr. J. Romilly Allen, " Pre-Norman Sculptured Stones at Heysham and Halton, Lancashire." 2. Mr. E. Walford, " The Law of Burial in Woollen."

THURSDAY, FEB. 18...Royal, Burlington-house, W., 4½ p.m.

Antiquaries, Burlington-house, W., 8½ p m.

Linnean, Burlington-house, W., 8 p.m. 1. Mr. A. D. Michael, " Acari of genus *Glycephagus* found in Moles-nests." 2 Mr. John Ball, " Botany of Western South America."

Chemical, Burlington-house, W. 8 p.m. 1. Mr. W. H. Perkin, " The Constitution of Crude Oleic Acid, as indicated by its Magnetic Rotation ;" and " The Magnetic Rotation of Allylacetic Acid and Diallylmalonic Ether." 2. Mr. W. Collingwood Williams, " Reactions supposed to yield Nitryl Chloride." 3. Messrs. A. E. Jordan and T. Turner, " The condition in which Silicon exists in Cast Iron."

London Institution, Finsbury-circus, E.C., 7 p.m. Mr. R. A. Proctor, " New Stars."

Society for the Encouragement of Fine Arts, 9, Conduit-street, W., 8 p m. Mr. Geo. C. Haité, " The Tendencies of Modern Art."

Royal Institution, Albemarle-street, W., 3 p.m. Prof. W. Chandler Roberts Austen, " Metals as affected by Small Quantities of Impurities." (Lecture IV.)

Historical, 11, Chandos-street, W. 8 p m.

Numismatic, 4, St. Martin's-place, W.C., 7 p.m.

FRIDAY, FEB. 19 ... SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. (Indian Section.) Mr. F. C. Danvers, " Historical and Recent Famines in India."

United Service Institute, Whitehall-yard, S.W., Rear-Admiral The Hon. R. Freemantle, " Naval Tactics."

Royal Institution, Albemarle-street, W., 8 p.m. Weekly Meeting. 9 p.m. Prof. W. H. Flower, " The Wings of Birds."

Geological, Burlington-house, W., 1 p.m. Annual General Meeting.

Geologists' Association, University College, W.C..

Philological, University College, W.C., 8 p.m. Mr. Henry Sweet, " Old English Contributions."

SATURDAY, FEB. 20 ... Royal Institution, Albemarle-street, W., 3 p.m. Prof. A. Geikie, " The History of Volcanic Action in the British Isles." (Lecture IV.)

Journal of the Society of Arts.

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FRIDAY, FEBRUARY 19, 1886.

All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

NOTICES.

COLONIAL & INDIAN EXHIBITION.

With the present number of the *Journal* is issued, as a Supplement, a plan of the forthcoming Exhibition, and on page 305 will be found a description of the general arrangements of the Exhibition.

CANTOR LECTURES.

On Monday evening, 15th inst., Professor F. GUTHRIE, F.R.S., delivered the first lecture of his course on "Science Teaching," In which he treated of science as an element in education.

The lectures will be printed in the *Journal* during the Easter recess.

Proceedings of the Society.

FOREIGN & COLONIAL SECTION.

Tuesday, February 16th, 1886; Sir SAUL SAMUEL, K.C.M.G., in the chair.

The paper read was—

PRESENT STATE OF THE COLONIAL POSSESSIONS OF GREAT BRITAIN.

By Robert James Mann,
M.D., F.R.C.S., F.R.G.S., &c.

The near approach of the great Exhibition, which is designed to illustrate, during the summer of the present year, the productive industries of the colonial possessions of the empire, suggests the appropriateness of a summary and review, at the present time, of the resources and condition of those dependencies. This sketch is placed before the Society in anticipation, it is hoped, of a more exact account of the arrangements which are in progress for the illustration of the industries and productions of these interesting communities at a more advanced period, when the maturing organisation of the scheme will enable this to be more advantageously done.

In entering upon the consideration of this subject, it will be well that it should be borne in mind how recently in the march of history it is that the kingdom of Great Britain was virtually altogether compressed within the limits of the two islands which now form the centre of its civilising and colonising operations. The East India Company's first settlement in India, at the Fort of Surat, was formed in 1611, but little more than two centuries and a half ago; Jamaica was occupied in 1670; Canada was finally taken from the French in 1763; Port Jackson, in New South Wales, received its first settlement in 1788, or less than a full century ago; and the first occupation of the Cape of Good Hope by Great Britain occurred seven years after that.

The Dominion of Canada, extending from the Atlantic to the Pacific, including a territory about as large as Europe, and comprising in exact numbers an area of about 3,580,310 square miles, contains within itself the provinces of Upper and Lower Canada, New Brunswick, Nova Scotia, Prince Edward Island, British Columbia, Manitoba—the land formerly in the hands of the Hudson's Bay Company, and the vast North-West Territory. The population is estimated in round numbers at about 4,588,000. Canada, Nova Scotia, and New Brunswick were joined together in 1867. The province of Manitoba, originally the Red River Settlement, and the north-west territory, were admitted into the union in 1871. British Columbia was received in 1871, and Prince Edward Island in 1873.

The value of imports for Canada in the year 1852 was £4,168,437; the value of exports, £3,145,399. The value of imports in 1884 was £24,248,000; of exports, £18,942,000. The public revenue in 1884 was £6,662,000; the public expenditure, £6,430,000; and the public debt, £50,517,000.

The timber trade, agriculture and cattle, are the largest sources of production in

Canada proper; the fisheries are very valuable. The mineral wealth is large, although as yet but imperfectly developed. Mineral oil is produced in large quantity; coal and iron are abundant in Nova Scotia and New Brunswick. Horses and sheep are bred largely in Prince Edward Island; 394,000 tons of coal were raised in British Columbia and Vancouver Island in 1884, of which 306,000 tons were exported. Many thousand tons of salmon are tinned and exported every year; the furs collected within the Dominion include minx, marten, sable, silver-fox, bear, beaver, sea and land otter, seal, deer and elk. The Canadian Pacific Railway passes through the centre of British Columbia. The North-West Territory, traversed by the same railway, stretches towards the north from the 49th parallel of north latitude to the Arctic frontier of the continent. It has an area of more than 2,665,000 square miles, with a population scarcely exceeding 56,000, of which nearly one half are Indians; 150,000 square miles of this territory are conceived to be suitable for agricultural operations. It has also large mineral deposits, including coal and gold, and possesses about 10,000 miles of navigable rivers.

Newfoundland, the only part of British North America which has not been included in the Dominion of Canada, has an area of 40,200 square miles, and as recently as 1874 had a population scarcely exceeding 161,389. Its chief wealth consists in cod fish, cod and seal oils, sealskins, and copper. In 1883, the exports of these products were of the value of £1,175,000. The total value of imports and exports at that time was £3,372,000. The public revenue was £283,000, and the public expenditure, £257,000. The public debt, £322,000.

Australasia, as a British possession, includes Australia, New Zealand, Tasmania, a portion of New Guinea, and several small islands between the Indian and Pacific oceans. The area of the entire space is estimated at 3,169,389 square miles, and the population amounts to not less than 3,223,000.

Australia proper, with an area of 3,031,771 square miles, and with a population which, at the close of 1884, was estimated at something more than 2,538,000, is distributed into five colonial departments, New South Wales, Victoria, Queensland, South Australia, and West Australia. The centre of the continent is a barren stony desert, but rich grazing pasture land is spread all round the coast, upon which there were 58,500,000 sheep feeding at the end of 1884. Including Tasmania and New Zealand, there are 5,755 miles of railway, and 59,956 miles of telegraph communication. The land was first brought within the knowledge of the civilised nations of the world in 1770 by Captain Cook, when he came upon it in the course of his great voyage of circumnavigation in his eastern progress from Cape Horn. But it had been casually sighted by French, Dutch, and other English navigators at an earlier date. Flinders sailed round the entire land in 1802, and conferred upon it the now universally accepted name of Australia. The first English settlement was formed at Port Jackson, now Sydney, in 1788.

The public revenue of all Australasia amounted, in 1884, to £22,285,000; and the public expenditure to £20,659,000. The public debt at that time was £97,944,000. The value of imports, £64,353,000; and of exports, £44,336,000. In the same year, shipping, representing 10,886,000 tons, entered and cleared out of the various ports, irrespective of mere coasting trade.

New South Wales, in the first instance, comprised the whole of the eastern side of Australia. It was so called by Captain Cook. Its first settlement consisted of the penal station formed at Port Jackson, by Captain Arthur Phillip, in 1788. The colony, reduced to its present dimensions by the separation from it of Victoria and Queensland, has an area of 310,700 square miles, about three times the extent of Great Britain and Ireland, and at the end of 1884 contained a population of 921,000. In 1850, its population was 265,500. The country is rich in its agricultural capacities, and had above 30,000 sheep upon its pastures in 1884. In the same year it exported 441,000 gallons of wine, and 173,986,000 lbs. of wool. It produces gold, silver, coal, iron, copper, tin, antimony, kerosine, and tobacco. The public revenue in 1884 was £7,117,000, and its expenditure £6,853,000. Its public debt at that time was £24,600,000. The value of its imports was £20,826,000, and of its exports £18,251,000. There were 1,688 miles of railway in operation, and 18,681 miles of telegraph. The native population amounted to a little more than 5,600. The chief town, Sydney, possesses a university, an astronomical observatory, a royal mint, and a free public library. Mr. Froude describes the physical characteristics of the port of Sydney, in a narrative of his visit to the Australian colonies last year just published, and termed

"Oceana," in very glowing and graphic words. He reached it by railway from Melbourne, and in speaking of the termination of his journey he says :—

"In the forenoon we ran down from the hills to the plains which we had seen from our window, stretching blue and hazy to the horizon. Ten miles from Sydney the detached cottages became thicker, villages smartened themselves into suburbs. The city spread inland to meet us, and we had not been many minutes running between houses before we arrived at the station. Sydney proper—the old Sydney of the first settlement—stands on a long neck of land at the mouth of the Paramatta river, between two deep creeks, which form its harbour, that is, its inner harbour, where its docks and wharves are. Port Jackson, the harbour proper, from which these are mere inlets, is the largest and grandest in the world. A passage about a mile wide has been cut by the ocean between the wall of sandstone cliffs which stretch along the south-west Australian shores. The two headlands stand out as gigantic piers, and the tide from without, and the fresh water from within have formed an inlet shaped like a star-fish, with a great central basin, and long arms and estuaries which pierce the land in all directions, and wind like veins between lofty sandbanks. The rock is grey or red; worn by the rains and tides of a thousand human generations, it projects in overhanging shelves, or breaks off into the water, and lies there in fallen masses.

"The valleys thus formed, and widening and broadening with age, are clothed universally with the primeval forests of eucalyptus and dark Australian pine—the eucalyptus in its most Protæan forms—and, staining its foliage in the most varied colours, the red cliffs standing out between the branches, or split and rent where the roots have driven a way into their crevices. In some of these land-locked reaches, except for the sunshine, and the pure blue of the water, I could have fancied myself among the yews and arbutuses of Killarney. The harbour is on an average, I believe, about nine fathoms deep; the few shoals are marked, and vessels of the largest size lie in any part of it in perfect security. Sydney itself is about seven miles from the open sea. The entire circuit, it is said, if you follow the shore round all the winding inlets from bluff to bluff, is 200 miles. There is little tide, and, therefore, no unsightly mud banks are uncovered at low water. It has the aspect and character of a perfect inland lake, save for the sea monsters, the unnumbered sharks which glide to and fro beneath the treacherous surface."

Of the public gardens at Sydney, he says :—

"On the first evening we were left to ourselves. I walked up in the twilight to the esplanade at the public garden, and I think I have never in my life gazed on a scene so entirely beautiful. It was not for the trees and flowers; they were lovely, and anywhere in Europe they would be celebrated as a wonder. But there was not the science, there was not the elaborate variety which I had admired at Ballarat. Sydney is many degrees hotter. Tropical plants, which there require glass to shelter them, at Sydney breathe luxuriantly the free air of heaven; but the roses and lilies of the temperate zone, which are the fairest flowers that blow, grow feebly here, or wil not grow at all. It is the situation which gives in the Sydney garden so exquisite a charm. The ground slopes from the town to the sea with inclining lawns, flower beds, and the endless variety o tropical flora. Tall Norfolk Island pines tower up dark into the air, and grand walks wind for mile along continually varying landscapes, which are framed by the openings in the foliage of the perfumed shrubs. Within the compass of the garden the sea forms two deep bays, one of which is reserved for the ships of the squadron. Fine vessels lay at anchor there, their spars black against the evening sky, and the long pennants drooping at the masthead; the *Nelson* sitting like a queen in the midst of them, the admiral's white flag hanging over the stern. Steam launches were gliding at half-power over the glassy waters, which were pink with the reflection of sunset. Boats were bringing off officers and men who had been on leave on shore; the old order, form, and discipline in the new land of liberty—the shield behind which alone the vaunted liberty is possible. Behind the anchorage were rocky islands, with the deserted ruins of ancient batteries, now useless and superseded by ampler fortifications inside the bluffs. Merchant ships lay scattered over the outer harbour, and a yacht or two lay drifting with idle sails. Crowded steam ferry boats were carrying the workmen from the city to distant villages. On wooded upland or promontory shone the white palaces of the Sydney merchants, and beyond again were the green hills, softened by the distance and the glowing dusk into purple, which encircle the great inlets of Port Jackson.

"As a mere picture it was the loveliest that I had ever looked upon. The bay at Rio, I am told, is equally fine, and indeed finer, being over-hung with mountains. There are no mountains at Sydney. The Blue Range is far off on the land side, and makes no part of the harbour scenery. But one does not always wish for grandeur. Sydney has the perfection of soft beauty, and one desires no more. At Rio, moreover, if the English flag is seen, it flies as a stranger. At Sydney there are the associations of home—we are among our own people, in a land which our fathers had won for us."

The tonnage of the vessels that now enter and leave the port of Sydney in the year is larger than that of the vessels of the port of London in the first year of Queen Victoria. The edge of the harbour is given up to warehouses, commercial chambers, and offices, and banks and buildings which, during business hours, are packed with a busy crowd. But narrow and winding streets in the busy part show that it is not a modern town, but a place that has grown in the old English fashion. There are handsome streets with grand fronts and arcades, mingled with lanes and alleys with dull and unsightly aspects. Trees are planted wherever there is room for them. The city is interesting, also as being the most ancient town in Australia. Having been the seat of the first settlement, it is now approaching one hundred years old.

Victoria, originally the Port Philip district of New South Wales, was separated from it as a distinct colony in 1851. It consists of the south-east corner of Australia, where the land projects furthest into the southern latitudes, and contains an area of 87,884 square miles, with a coast-line of 600 miles. In 1850 its population was 30,600; and in 1884 was 961,000, including about 13,000 Chinese. Its rapid progress in prosperity and relative wealth is due to the discovery of gold in 1851. At the end of 1884, 33,023,985 ozs., or nearly 1,624 tons of gold, of the estimated value of £212,095,940, had been produced. Tin, antimony, and some other metals, to the value of £800,000, had also been yielded by the mines. There were 1,663 miles of railways, and 4,020 miles of telegraph at work in 1884. Wool is also a great staple production of the colony. There were, at the same period, 10,637,000 sheep on the pastures, the estimated produce of wool for the year being 61,369,000 lbs., valued at nearly £4,000,000 sterling. In the same year 723,000 gallons of wine were made, which exceeded the yield of the previous year by more than 200,000 gallons. Steam-power, amounting to 18,700 horses, was employed in the mines and manufactories, involving the employment of capital of more than £10,000,000. Melbourne, the chief city, has a university, public museum, mint, astronomical observatory, and public library, and a population of 325,000. The public revenue, in 1884, was £6,290,000, and the public expenditure, £6,212,000. The public debt was £28,331,000. The value of imports £19,201,000, and of exports £16,050,000.

In his "Oceana," Mr. Froude gives a most interesting account of the present state of affairs at Ballarat, the first gold mine opened out forty years. He found it a well-ordered and really attractive town, containing 40,000 inhabitants, created, as if by Aladdin's lamp, in the wilderness. In 1844, it was an arid treeless hollow lying between low hills, with a scanty brook trickling down the middle of it, with the valley and hill-side dotted over with tiny tents, with some tens of thousands of human beings flinging up soil and sand heaps like Bactrian ants, and with bushrangers watching in the forest to intercept the gold on its way down to the sea. As Mr. Froude approached Ballarat he left the forest, and came among plantations. The *Pinus insignus,* eucalyptus, magnolia, and Moreton Bay fig tree, were planted in all directions, and in all convenient places, as the town began to rise, and, consequently, as the houses multiplied the trees grew which were to shade them. Having grown ten times as fast as they would have done in England, there are now magnificent trees everywhere—in yards and courts, in streets and squares. They overtop the chimneys, and give an air of grace and beauty to the common-place architecture. Mining is still the principal industry of the place. But the surface diggings have been long exhausted, and the work is now carried on in the solid quartz rock underground, which is quarried and crushed. The town is, therefore, interspersed with the inevitable engine works, heaps of rubble and cinder, and high scaffoldings of mine machinery with wheels revolving, and the black arms of cranks rising and falling. The gold mining was still paying in its way; that is to say, the annual yield of the Victorian mines was from £4,000,000 to £5,000,000, and the cost of production about the same, but this implies that a great number of people were earning high wages, that local trade and business were flourishing, and that thousands of families were maintained in comfort.

But the city is also a great agricultural centre, and is becoming more so every year. One passage in "Oceana" in relation to this important characteristic is so striking and suggestive that it deserves to be reproduced here. Mr. Froude says:—

"We were taken back through what was termed the 'fertile district' of Ballarat. The wheat was gone; the thick stubble only remained to show where it had been; but oats, barley, peas, beans, potatoes, grew in the fields, and after the sight of them I could believe Herodotus' account of the crops grown on the plains of Babylon. E——" (his companion), "who knows what agriculture is, and had been all over the world, said that he had never seen the like of it. An oat crop was half-cut. Where the reaping machine had stopped, it was standing like a wall—so thick that a horse could scarcely have forced a way through it, and so clean of weeds that there was nothing like one visible. Weeds, indeed, are said to be a product of high civilisation. For seventeen years they have been cropping the land without manuring it, and there is no symptom of exhaustion; each harvest is as rich as the last. When earth is so kind, men cannot choose but be happy. The human occupiers of these farms live each on his own freehold, or, if tenants, with no danger of disturbance. They have pretty houses, smartly kept, and bright with paint; and trellis-vines creep over the verandahed fronts, and the slopes or lawns are bright with roses. The orchards around them reminded me of the Boers' orchards in the Free State; peaches and apricots, almonds, figs, pears, and apples, all thriving as if they had taken fresh life in the new land where they found themselves; and the men and women seemed as thriving too, with the courteous manners of independent gentlemen and ladies. If English farmers and farm-labourers could but see what I saw that day (and I am informed that other parts of the colony were as much richer than this as this was richer than my own Devonshire), there would be swift transfers over the seas of our heavily-laden 'agricultural population.' The landed interest itself —gentry and all—will perhaps one day migrate *en masse* to a country where they can live in their own way without fear of Socialism or graduated income-tax, and leave England and English progress to blacken in its own smoke."

Mr. Froude's description of the public park at Ballarat is scarcely less worthy of notice. In reference to it, he says :—

"Finally my driver brought me to the gates of the park, where we found the rest of our company assembled. It then appeared how skilfully our entertainment had been arranged. We had been passed through purgatory in the morning, that we might enjoy paradise afterwards—literally paradise—for paradise means park, and here was a park worthy the name. I have already expressed my admiration of the Australian gardens, but this at Ballarat excelled them all. It was as if the Town Council had decided to show what gold and science could do with such a soil and climate. The roses which bloom ill on the hotter lowlands were here, owing to the height above the sea, abundant and beautiful as in Veitch's nurseries at midsummer. Besides roses, every flower was there which was either fair to look upon, or precious for its fragrance. There were glass houses to protect the delicate plants in the winter; but oranges and camellias, which we know only in conservatories, grow without fear in the open air, and survive the worst cold which Ballarat experiences. A broad grand walk led up the middle of the grounds, with lateral paths all damply kept. Dark shadowy labyrinths conducted us into coo grottoes overhung by tree ferns, where young lovers could whisper undisturbed, and those who were not lovers could read novels. Such variety, such splendour of colour, such sweetness, such grace, in the distribution of the treasures collected there, I had never found combined before, and never shall find again."

Mr. Froude visited the vineyard of St. Hubert, in the valley of the Yarra, belonging to Mr. Castella, a Swiss gentleman from Neufchatel, the most notable and successful attempt, perhaps, at wine-growing that has yet been made in Victoria. He found the vines all in full leaf, and in excellent condition, over 300 acres of land, and the buildings supplied with ample presses, hogsheads, and cellars. The house was a large roomy structure, with high-gabled roofs, deep verandahs, and with a central tower, and numerous detached rooms scattered about the shrubberies for the accommodation of guests. Mr. Froude walked out from his own particular lodgings amongst the trees, before breakfast in the morning, to make an extemporised feast upon ripe greengages which hung in countless thousands above his head.

Mr. Froude went to see the great trees at Fernshaw, in a mountain glen near the sources of the Yarra, and about twenty miles from St. Hubert's vineyard. The route lay through woods of gum trees with clean straight stems rising two hundred feet before sending out any branches. There was no undergrowth, excepting tree ferns thirty feet high, and the boughs were joined overhead to form a verdant roof, supported on gray columns which rose one beyond the other all round, and constituted aisles suggesting the idea of an immeasurable cathedral. The great trees stand in a spot well sheltered from wind, and where they enjoy also the advantage of a congenial soil. Their average height is between 350 and 400 feet, and one tree which was measured proved to be 460 feet high. The girth of another tree near the road was forty-five feet at the height of the shoulder. Mr. Froude speaks of these trees as being 100 feet higher than the great conifers in the Yosemite Valley of California.

South Australia was formed into a distinct colony in 1863; but it includes in its boundaries the centre of the continent up to the latitude of 11° south, and has an area of 903,690 square miles, with a population of 313,000. In 1850 its area was 383,300 square miles, and its population 63,000. Its first settlement was formed in 1836. It is principally an agricultural and pastoral district. Its yield of wheat in 1854 was over 14,000,000 bushels, with an export of breadstuffs valued at £2,491,000, and of wool of 46,741,000 lbs. The produce of wine in that year was over 473,000 gallons. The number of sheep feeding on the pastures was 6,696,000. Copper is extracted in considerable quantity. In 1884 there were 1,060 miles of railway, and 5,291 miles of telegraph in operation. The public revenue was £2,024,000, and the public expenditure £2,398,000; the public debt, £15,473,000; the imports of the value of £5,749,000, and exports of the value of £6,623,000. The population of Adelaide, the chief town, amounts to about 15,000.

Queensland was separated from New South Wales in 1859. It comprises an area of 668,497 square miles, equal to 5½ times the extent of Great Britain, and includes the whole north-eastern portion of the continent. The population, which was 34,800 in 1861, had reached 309,000 in 1884. In that year the produce of sugar was 33,300 tons; wool to the value of £1,889,000; gold of the value of £923,000; silver and lead to the value of £25,000; tin to the value of £228,000; pearls to the value of £94,000; sugar to the value of £454,900; and a small quantity of rum and timber were also exported. The mineral deposits and timber are of considerable value. There were 253,000 horses, 4,266,000 cattle, and 9,308,000 sheep feeding upon the pastures, and 51,000 pigs in the colony. There were 1,007 miles of railway, and 11,300 miles of telegraph in operation. The public revenue was £2,720,000, and the public expenditure £2,819,000; the public debt £16,419,000. The imports were of the value of £6,381,000, and he exports of the value of £4,673,864.

The first settlement was formed on the River Brisbane, in Moreton Bay, in 1823.

Western Australia, the old Swan River Settlement, comprises an area of 975,824 square miles, with a coast line of more than 1,200 miles. Much of the land is heavily covered with timber, mostly eucalypti, of very large size. The population was under 6,000 in 1850, and about 33,000 in 1884. The first settlement was founded in 1829. The vine, the olive, and the fig thrive. There are 124 miles of railway in operation. Wool, timber, especially sandal wood, lead, copper, pearls, whale oil, and guano are among the exports. The public revenue was £290,000 in 1884, and the public expenditure £291,000; the public debt was £765,000. The value of the imports was £521,000, and of the exports £405,000.

Tasmania, at first known as Van Diemen's Land, and so named from the governor of the Dutch Indian possessions at the time of its discovery in 1642 by Tasman, comprises an area of 26,215 square miles. A penal settlement was formed upon it by Lieut. Bowen in 1803. It was separated from New South Wales, and made into a distinct colony in 1825. Its use for the reception of convicts was discontinued in 1853, and the name was changed from Van Diemen's Land to Tasmania. Wool, gold, tin, and various fruits are the chief productions of the colony. Wheat grows with great luxuriance. The native woods are of very great excellence. The value of the tin exported in 1884 was £301,000, and of the gold £132,000. Coal and iron are abundant. The population in 1861 was 90,000, in 1884 it was 130,500. The value of the preserved fruits exported in 1884 was nearly £171,000. There were 215 miles of railway, and 1,716 miles of telegraph in operation. The public revenue was £549,000, and the public expenditure £584,000; the public debt was £3,202,000. The value of the imports was £1,656,000, and of the exports £1,475,000. The population of Hobart, the chief city, was 18,000.

New Zealand was formed into a separate colony in 1841. The first settlement upon it was made in 1814; the three islands comprise an area of about 104,403 square miles, a little less than the superficial extent of Great Britain and Ireland, and two-thirds of the land are considered fit for agriculture and grazing. The adjacent group of the Chatham Islands contains 377 square miles. The population in 1851 was 26,700; at the end of 1884 it was 564,000; exclusive of 44,000 natives. The auri pine and gum are largely produced an d exported. Coal, iron, copper, and gold are amongst the mineral productions; the chief export is wool. The public revenue in 1884 was £3,707,000; and the public expenditure £4,101,000; the public debt was £32,860,000. The value of the imports was £7,663,000; and of the exports £7,091,000. The population of Wellington, the chief town, is 22,000; and of Auckland, the old capital, 30,000.

Wellington stands upon the north island, near the western entrance of Cook's Straits, which separate the north from the south island. Auckland, the old capital, is upon the east coast of the north island, one hundred miles south of the northern extremity, at the bottom of the deep Hauraki Gulf, and upon an isthmus of seven miles wide, from the more elevated portions of which both seas are visible. Near the entrance of the Hauraki Gulf, thirty miles from Auckland, and under the shelter of a large Barier Island, Sir George Grey's Island of Kawau is placed. Auckland has an average temperature resembling that of the Riviera. Oleanders, orange trees, and fern-palms thrive in the outer air. The "four eights," the ideal of the workman's felicity—that is, eight hours to work, eight to play, eight to sleep, and eight shillings a day,* Mr. Froude found to be a substantial reality in Auckland.

The kauri pine, one of the chief treasures of New Zealand, grows in enormous forests. The timber which it yields is fine grained, tough, tenacious, does not split or splinter in working, does not warp, is very durable, and as soft to the chisel as deal. It furnishes a gum like amber, which is used in a similar way for the manufacture of ornaments, and which constitutes a valuable article of export. A kauri pine takes 800 years to mature. The totara, which grows interspersed with it, is like a giant eucalyptus, and is generally embraced in the coils of a serpent-like parasite, called the rata. The black pine, cypress, and puketu, are all forest trees. There is usually a dense thicket under the tall trees—with the exception of the kauri, which is for the most part destitute of undergrowth — of shrubs with glossy leaves, like the magnolia or laurel, of aromatic bushes, of flowering bushes with scented blossoms winding about their branches. The tree fern here has its home. In Sir George Grey's Island he has planted pretty well all the known trees and shrubs of the world. Mr. Froude, in "Oceana," gives a very charming account of the visit he made to Sir George Grey. He also draws attention to the large amount of the New Zealand debt, compared with the numbers of its population, which he does not think altogether a satisfactory feature to dwell upon; on the other hand he was very favourably impressed with the capabilities of the land to support a large population. The climate ranges from that of the Bay of Naples, to that of the North of Scotland. There is abundant rainfall, great rivers and mountains, a soil luxuriantly rich, and a clothing of magnificent forest. There are mountain ranges grander than the giant bergs of Norway; glaciers and water falls for the hardy hill-men; sheep walks for the shepherds; and coasts with infinite diversity of contour to serve as nurseries for seamen. In speaking of the North Island, Mr. Froude says:—

> "No Arden ever saw such forests, and no lover ever carved his mistress's name on such trees as are scattered over the ground. If it lies written in the book of destiny that the English nation has still within it great men who will take a place among the demigods, I can well believe that it will be in the unexhausted soil and spiritual capabilities of New Zealand that the great English poets, artists, philosophers, statesmen, and soldiers of the future will be born and nurtured."

The number of sheep in New Zealand and Tasmania, taken together, is estimated at 16,000,000.

The *Cape Colony*, held by Great Britain since 1806, has an area of 213,636 square miles, and a population of 1,122,000. The population was 285,000 in 1850. Wool and wine are staple products of the colony, and horses, cattle, sheep, and ostriches, are reared in the pastoral districts. The export of wool in 1884 was 37,270,000 lbs.; of angora hair 4,329,000 lbs.; and of ostrich feathers 233,400 lbs.; 20,348 tons of copper, of the value of £405,400 lbs., were produced in Namaqualand division in that year, and the value of the diamonds from Kimberley exceeded £2,807,000. The public revenue in 1884 was £2,499,000, and the public expenditure was £5,374,000; the public debt £19,658,000; the value of the imports was £5,260,000, and that of the exports was £7,031,000. The population of Cape Town, at Table Bay, was 45,000 in 1873. There are, at the present time, 1,523 miles of railway, and 8,663 miles of telegraph in operation. Griqualand east, and Fingoland, were annexed to the colony in 1877 and 1879; Tembuland was added in 1885; the territory of St. John's in 1884; Walfish Bay in 1884; and Pondoland in 1885.

Natal comprises an area of 18,750 square miles, with a sea-coast of 200 miles, and a population of 35,000 Europeans, 361,000 Zulu kafirs, and 27,000 Indian coolies. It was occupied as a British dependency under the Cape Colony in 1843, and became a separate colony in 1855. Sugar, coffee, indigo, arrowroot, ginger, tobacco, and cotton, are produced in the coast districts, and the pineapple there ripens in the open air. The upper district is chiefly pastoral, and occupied by sheep, cattle, and horses; wool, sugar, coffee, hides, and skins, and ostrich feathers are exported. The public revenue in 1884 was

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* This, it will be remembered, was alluded to in the paper read before the Society by Mr. Arnold White, on the 26th of January.

£610,000, and the public expenditure £746,000; the public debt was £3,215,000; the value of the imports was £1,675,000, and that of the exports £957,000. The population of Pietermaritzburg, the chief city, was 14,000; the value of wool exported in 1883 was £122,000 (15,829,000 lbs. in weight); of sugar £122,000; of hides and skins £57,000; of angora hair £15,000.

The island of *Mauritius*, which became a dependency of Great Britain by conquest from the French, in 1810, has an area of 713 square miles, almost entirely occupied by the cultivation of sugar. The resident population in 1884 was 370,000, of which 253,000 were Indians, descended from coolies originally imported for the cultivation of sugar. The Seychelles and Rodriquez group of islands, with an additional area of 350 square miles, and with a population of 15,000, are outlying departments of the Mauritius. Sugar, rum, vanilla, and aloes fibre, are exported from the island, and rice and cotton manufactures are largely imported for the use of the coolies. In 1884 there were 92 miles of railway, and 92 miles of telegraph in operation in the island. The capital, Port Louis, has a population of 64,000; the public debt in 1884 was £906,000; the value of the imports £482,000, and that of the exports £356,000.

The recent annexation in *New Guinea* comprises an area of 88,550 square miles, of which 2,907 miles are contained in islands. The population is estimated at 137,500. The German portion of New Guinea comprises an area of 88,340 square miles, and a population of 297,000 inhabitants. The Dutch portion contains 147,550 square miles, and 250,000 inhabitants.

The *Fiji Islands*, situated in the South Pacific ocean, 1,100 miles to the north of New Zealand, were ceded to Great Britain in 1874. They comprise 225 islands, with a collective area of 7,740 square miles, and a population of 3,300 Europeans, 111,000 natives, and nearly 10,000 Indian and Polynesian labourers. The value of the imports in 1884 was £434,000; and that of the exports £345,000. The chief exports are cotton, sugar, pearl shells, maize, copra, cocoa-nut oil, and *bêche de mer*. The capital, Suva, is in the Island of Viti Levü. The Island of Rotumah was annexed in 1881.

British Guiana, comprising Demerara, Esequibo, and Berbice, on the South American mainland, has an area of 85,000 square miles, and has been a British possession since the peace of 1814. Sugar is its chief production, and forms 92 per cent. of the exports. The population in 1882 was 257,000. In 1884 the public revenue was £460,000, and the public expenditure £449,000. The public debt is £200,000. The value of the imports was £1,999,000, and of the exports, £2,322,000. The capital, George Town, has a population of 47,000.

British Honduras, in Central America, has an area of 7,562 square miles. It contains a population a little exceeding 27,000; the land is covered with primeval forests, interspersed with savannahs; sugar canes, and coffee and cocoa trees thrive; mahogany and logwood are exported. In 1884, the export of mahogany was 7,527,000 feet, and of logwood 15,000 tons. The public revenue in 1884 was £51,000, and the public expenditure £53,000. The value of the imports in that year was £237,000, and that of the exports £317,000. The capital, Belize, contained a population of nearly 6,000 in 1881.

The *Falkland Isles*, off the eastern entrance of the Straits of Magellan, consisting of two large islands, and about 100 islets, contain, altogether, an area of 4,740 square miles, and a population of 1,500 individuals. They were annexed to Great Britain in 1771, and occupied by a settlement in 1833, as a protection to the whale fisheries prosecuted in the neighbouring ocean. Small quantities of oil, hides, tallow, sealskins, and frozen meat are exported. South Georgia, an island of 1,570 square miles, situated 800 miles towards the south-east, is appended to the government of the Falkland Islands. The public revenue and expenditure of the Falkland Isles are about £8,000 each; the imports are valued at £27,000, and the exports at £69,000.

The British possessions in the *West Indies* consists of—1, Jamaica, 4,193 square miles; 2, Trinidad, on the Venezuelan coast of South America, 1,754 square miles; 3, The Caicos Islands, between the Bahamas and San Domingo, 223 square miles. The Leeward Islands—4, Antigua and Baruda, 183 square miles; 5, Montserrat, 35 square miles; 6, St. Christophers (St. Kits), with Nevis and Anguilla, 685 square miles; St. Domingo, 290 square miles; 8, the Virgin Islands, 64 square miles, at the north-western termination of the group. The Windward Islands—9, Tobago, 114 square miles; 10, Grenada, 119 square miles; 11, St. Vincent, 132 square miles; 12, St. Lucia, 450 square miles; 13, Barbadoes, 166 square miles; lying off in the ocean to the eastward of the Windward

Islands—14, the Bahamas, thirty islands stretching down from Florida towards the great island of San Domingo, 5,794 square miles. These islands possess altogether an area of 13,750 square miles, and a population of 1,250,000. They all yield tropical produce, such as sugar, coffee, and cocoa. Trinidad yields asphalt. Tobago is covered with tropical forests. The value of the imports of the islands in 1883 was £6,687,000, and the value of the exports was £6,674,000.

The *Bermudas*, in the West Atlantic, 630 miles from the coast of North Garolina, consist of 300 small islands, with a collective area for the entire group of 41 square miles, and a population of 14,000. They were annexed to Great Britain in 1609. The revenue is £28,000, the expenditure, £29,000, the public debt, £3,300. The value of imports £75,000, and of exports £2,500. The Bermudas contain an important fortified naval station. The islands are becoming a favourite winter resort for the Americans.

St. Helena, in the South Pacific, has an area of 47 square miles, and had a population in 1881 of 5,000. It was taken by Great Britain from the Dutch in 1693, and was governed by the East India Company, under the provisions of its charter, until 1833. The chief trade consists in furnishing provisions and water to passing ships. Its revenue is £10,000, and its expenditure £10,000. It has a public debt of £6,700. It imports are of the value of £27,000, and its exports £1,100.

The Island of *Ascension*, in the South Pacific, was first occupied as a naval station by Great Britain in 1815. It has an area of 35 square miles. It is under the charge of the Admiralty. The value of its imports are £4,000. Its exports are turtles and birds' eggs. Its chief value is as a naval depôt, and it possesses a steam factory, naval and victualling yards, a coal store, and very excellent hospitals.

The *West African Settlements* are Sierra Leone and the Gambia.

Sierra Leone has an area of 600 square miles, and a population of 60,000, 163 only being Europeans. The revenue is £73, the expenditure £82,000, the public debt £50,000. The value of imports £464,000, and of exports £377,000. The chief exports are cocoa-nuts, ginger, ground nuts, india-rubber, gum copal, hides, and palm oil.

The settlement on the *River Gambia* and the adjacent islands contains an area of 21 square miles, and a population of 44,000, of whom only 105 were Europeans. The chief export is ground nuts. The value of the public revenue is £28,000; and that of the expenditure £23,000.

The *Gold Coast* settlement, on the Coast of Guinea, has an area of 16,200 miles, and a population of 520,000. It was settled as a British colony in 1874. Gold, ivory, gum copal, monkey skins, and palm oil are exported. The revenue is £106,000; the expenditure £99,000. The value of the imports £515,000; and that of the exports £594,000.

Lagos, off the Slave Coast, was occupied in 1861 as a station to be turned to account for the suppression of the slave trade. The population is 75,000, of whom only 94 are Europeans. The revenue is £50,000, and the expenditure £37,000. Palm kernels to the value of £221,000, and palm oil to the value of £147,000, were exported in 1881. Lead ore, indigo, and cam wood are produced in the neighbouring territory.

The *Channel Islands*, comprising Jersey, Guernsey, Alderney, Sark, and Herm, are dependencies of the British Crown, not ranking properly as colonial possessions. They are remnants of the old Dukedom of Normandy, at one time subject to Great Britain. The entire area is 73 square miles, with a population of 88,800. The value of the imports in 1884 was £804,000; of the exports £868,000.

The *Isle of Man*, in the Irish Sea, has an area of 281 square miles, and a population of 54,000. Its revenue is £55,000; its expenditure £51,000; its public debt £225,000. It exports lead, iron, blende, slates, and agricultural produce.

The small Island of *Heligoland*, off the mouth of the Elbe, in the North Sea, was taken from Denmark in 1807. It has a population of 2,000; a revenue of £8,000; an expenditure of £7,000; and a public debt of £3,500.

The island of *Malta*, in the Mediterranean, has an area of 117 square miles, and a population of 156,000, exclusive of 5,000 soldiers and soldiers' families. The revenue is £8,000, the expenditure £7,000, and the public debt £5,500. Valetta ranks as an important fortified naval station. The island produces cotton, oranges, and potatoes.

Gibraltar, the fortified station at the entrance of the Mediterranean, has a population of 24,000, a revenue of £40,000, and expenditure of £50,000. The value of the imports is £796,000, and of the exports £22,000.

Cyprus, although administered by England, is still a part of the Ottoman Empire, a yearly subsidy of £92,000 being paid to the Porte. Its area is 3,584 square miles, its population 186,000, The value of its imports is £304,000, of its exports £287,000. Its chief produce is cotton and wine

The island of *Labuan*, occupied by Great Britain as an eastern station in 1848, contains an area of 30 square miles, and has a population of 6,000.

Hongkong, at the mouth of the Canton river, has an area of 32 square miles and a population of 160,000, comprising 7,600 Europeans. Its imports are of the value of £3,587,000, and its exports of £1,052,000.

British North Borneo has an area of 30,000 square miles, and a population, chiefly Mahomedan Malays, of 150,000. It produces tobacco, sago, gutta-percha, india-rubber, gum, timber, coal, and gold.

The *Straits Settlements*, in the Straits of Malacca, comprise Singapore, Penang, Welesley, Dindings, and Malacca, making up an area of 1,500 square miles, and with a population of 500,000. The seat of government, Singapore, has a population of 139,000.

Port Hamilton, a naval station and three islands off Corea, commanding the Strait from the Yellow Sea to the Sea of Japan, was occupied by Great Britain in 1884. It has a fine sheltered harbour between the islands, about two miles long, and a population of 2,000 inhabitants, chiefly engaged in the cultivation of millet.

The British Islands themselves, the seat of the central sea of the Empire, possess an area of 121,115 square miles, and a population of 36,400,000. The area and population of the colonies and the foreign possessions may, for the purpose of comparison with this centre, be conveniently classed in the following summary:—

	Area in square miles.		Population.
Australasia	3,181,344	..	3,500,000
North America	3,620,000	..	4,650,000
Africa	270,000	..	2,350,000
Eastern possessions	30,000	..	7,000,000
British Guiana	100,000	..	260,000
West Indies	13,750	..	1,350,000
European possessions	120	..	175,000
Various small settlements	96,170	..	200,000

The total of area and population of the colonial and foreign possessions thus amounts to an area of land of 7,433,000 square miles, and a population of 19,485,000. The extent of the land comprised in the colonial and foreign possessions is thus sixty-one times as large as the central islands of the Empire, and the population is a little more than one half that of the parent community. The 121,115 square miles of Great Britain and Ireland, by the addition of the colonial possessions, become 7,433,000 square miles.

The 36,400,000 of population, with the addition of the inhabitants of the colonial possessions, become 55,850,000.

The area of India, which it will be remembered is to be associated with the colonial possessions in the approaching Exhibition, is 1,558,254 square miles; and its population is estimated as amounting to 260,000,000. With the addition of India, therefore, the empire of Great Britain represents an area of 8,991,254 square miles, and a population of 315,885,000.

The revenue and public debt of the colonial and foreign possessions, are for the same classification of groups—

	Revenue.		Public debt.
The British Isles	£88,000,000	..	£740,000,000
Australasia	22,000,000	..	105,000,000
North America	8,000,000	..	51,000,000
Africa	6,250,000	..	23,000,000
Eastern possessions	3,000,000	..	2,800,000
British Guiana	100,000	..	200,000
West Indies	1,550,000	..	2,000,000
European possessions	255,000	..	380,000
Small settlements	500,000	..	250,000
India	80,000,000	..	165,000,000

The entire revenue of the colonial and foreign possessions, exclusive of India, is £42,055,000, or nearly half the revenue of the central community of the British Islands. The entire debt of the colonial possessions, exclusive of India, is £185,350,000, or something less than the fourth part of the debt of the central kingdom.

The revenue of India is only eight millions less than the revenue of the central Government, and its debt is less than a fourth part of the debt of the home community.

The trade of the various groups of the colonial possessions stand under the same classification, as—

	Annual value of trade, comprising imports and exports.
The British Isles	£685,985,000
Australasia	112,000,000
North America	42,650,000

	Annual value of trade, &c.
Africa	17,260,000
Eastern possessions	47,000,000
British Guiana	5,400,000
West Indies	13,650,000
European possessions	2,000,000
Small settlements	1,000,000
India	149,076,000

The value of the trade of the colonial possessions, exclusive of India, is close upon £241,000,000, or more than a third part of the value of the home trade.

The value of the trade of India, to the value of the home trade, is as £149,000,000 to £685,000,000.

Mr. Service, the Premier of Victoria, anticipates that in half a century the Australian colonies will possess a population of fifty millions, and in that sense, will constitute a second United States in the southern hemisphere. If the present rate of increase of these colonies were continued, that number would be exceeded. The population of Great Britain and Ireland is at the present time seven times more than it was in the protectorate of Cromwell. But including the inhabitants of the United States, the number of people in new lands who have descended from the old stock in the British Isles is double that of the number which remains in the mother country.

In speaking of his recent visit to Australia and New Zealand, and of the promise of their rapid advancement in prosperity, Mr. Froude says:—

"In the closing years of my own life I have secured for myself a delightful experience. I have travelled through lands where patriotism is not a sentiment to be laughed at—not, as Johnson defined it, 'the last refuge of a scoundrel,' but an active passion—where I never met a hungry man or saw a discontented face, where, in the softest and sweetest air, and in an unexhausted soil, the fable of Midas is reversed, food does not turn to gold, but the gold with which the earth is teeming converts itself into farms and vineyards, into flocks and herds, into crops of wild luxuriance, into cities whose recent origin is concealed and compensated by trees and flowers—where children grow who seem once more to understand what was meant by 'Merry England.' Amidst the uncertainties which are gathering round us at home—a future so obscure that the wisest men will least venture a conjecture what that future will be, it is something to have seen with our own eyes that there are other Englands besides the old one, where the race is thriving with all its ancient characteristics. Those who take 'leaps in the dark,' as we are doing, may find themselves in unexpected places before they recover the beaten tracks again. But let fate do its worst, the family of Oceana is still growing, and will have a sovereign voice in the coming fortunes of mankind."

The following passage, which is also taken from Mr. Froude's book, expresses the importance of these colonial possessions to the prosperity of the empire in such eloquent words, and in so undoubtedly true a form, that the author of this review of the present state of the colonial resources feels that the act will need no excuse on his part, if he presents the extract in Mr. Froude's own language, at the conclusion of what he has desired to place before the meeting upon this occasion. Mr. Froude says:—

"It has become doubtful even to the political economist whether England can trust entirely to free trade and competition to keep the place which she has hitherto held. Other nations press us with their rivalries. Expenses increase, manufactures languish or cease to profit. Revenue, once so expansive, becomes stationary. 'Business' may, probably will, blaze up again, but the growth of it can no longer be regarded as constant, while population increases and hungry stomachs multiply, requiring the three meals a day whatever the condition of the markets. Hence those among us who have disbelieved all along that a great nation can venture its own fortunes safely on the power of underselling its neighbours in calicoes and ironwork, no longer address a public opinion entirely cold. It begins to be admitted that were Canada, and South Africa, and Australia and New Zealand, members of one body with us, with a free flow of our population into them, we might sit secure against shifts and changes. In the multiplying numbers of our own fellow-citizens, animated by a common spirit, we should have purchasers for our goods from whom we should fear no rivalry; we should turn in upon them the tide of our emigrants which now flows away, while the emigrants themselves would thrive under their own fig-tree, and rear children with stout limbs, and colour in their cheeks, and a chance before them of a human existence. 'Oceana' would then rest on sure foundations; and her navy—the hand of her strength, and the symbol of her unity—would ride securely in self-supporting stations in the four quarters of the globe."

[Some views taken, by Mr. Froude's kind permission, from "Oceana" were exhibited on the screen during the reading of the paper.]

DISCUSSION.

Mr. P. L. Simmonds said that it was almost impossible to add anything to the excellent paper just read, but as one who had taken a great interest in the colonies, he might perhaps be permitted to make a few observations. A perusal of the last thirty volumes of the *Journal of the Society of Arts* would prove that he had, from time to time, advocated the interests, and helped to promote a knowledge of the resources of the colonies. Ten years ago, when reading a paper before the Colonial Institute on "Colonial Aids to British Prosperity," he pointed out the literal dependence of the mother country upon the colonies, and how much we were indebted to them for raw materials, and for purchasing so many of our manufactures. The Australian colonies alone took paper of us to the value of three millions yearly, and this one instance was sufficient to show that England's best customers were her colonies. As we are so soon to have a Colonial Exhibition, it may not be out of place to mention a few figures to show the progress which the colonies have made since the Exhibition of 1862. Dr. Mann had confined himself chiefly to the present position, but those who looked back could see the progress which had taken place since the introduction of railways, telegraphs, and the like. In 1861, the aggregate population of the colonies was 8,948,297, now it was 15,990,273; in 1861, the revenue was £14,058,129, and now it was £42,534,180. The tonnage entered and cleared in 1861 was 12,527,543; while now it was 70,774,436, Except in Canada, railways were scarcely known in the colonies in 1861, but they had now 19,014 miles, and 39,102 miles of telegraph wire. With regard to the trade, the total value of imports and exports was £97,815,131, as against £184,116,545. In cattle and sheep there was a large trade, and he little thought when he read his paper before the Institute that this trade would have increased to the extent it had done. In Australia the number of cattle in 1861 was 4,039,839; it was now 8,178,745; in the Cape there were 900,000 sheep in 1861, and now there were 12,100,000. The total live stock in the colonies in 1861 was 27,473,859, as compared with 96,024,699 at the present time. Flocks and herds were not only increasing, notwithstanding the severe droughts which had taken place, but the quality and quantity of the wool had improved, and 404,000,000 tons were now sent home, as compared with 75,740,000 tons in 1861. The trade in timber had also developed, and this would be much larger, were it not for the excessive rates for freight. He thought the resources of the colonies would surprise many who had not looked into the matter carefully, and he sincerely hoped that one result of the Colonial Exhibition would be the establishment of a colonial museum in this country. It would seem rather hard if the tens of thousands voted by the colonies to make the Exhibition a success were to be thrown away, instead of the exhibits being preserved for the benefit of manufacturers and others.

Mr. CORNISH said there was one slight error in the paper worth noticing, viz., that it was stated that the gold fields were opened in Ballarat forty years ago; it should have been thirty-five years ago. With regard to the statement that the produce of gold only just paid expenses, he might say that one-third of the gold product of Victoria had paid in dividends upwards of one million sterling.

Dr. MANN said the statement, made upon the authority of Mr. Froude, was only that, at the present time, gold mining in Victoria was just paying its expenses.

Mr. CORNISH said that the gold fields had been the means of calling much attention to the Australian colonies, and gold mining was one of the greatest enterprises which England could support in the way of assisting the colonies. At present there were 50,000 miners in this industry, 26,000,000 sterling was produced annually, and 150,000 miners could be at once put to profitable employment, provided the requisite capital was furnished for procuring better machinery. The effect on English commerce would be very great if this capital was provided. He did not think there could be any more profitable industry in the world than gold mining. He should be sorry if at the forthcoming Exhibition it was not intended to have a battery at work in order to show the full operation of mining, and the means by which gold was obtained, as he thought this would prove the most interesting exhibit in the Exhibition. The timber resources of the colonies had as yet been paid little attention to in England, but this was a subject well worthy of attention, for in Western Australia alone there was a class of timber so valuable that it had only to be known in order to come at once into extensive use.

Mr. T. DE MESCHIN suggested that in the forthcoming Exhibition a small map, about the size of a post-card, should be prepared giving the particulars of the products of each colony. Such a map had been prepared for the Brussels Museum, and much information having been derived therefrom, it was to be hoped that a similar experiment would be tried at the Colonial Exhibition.

Mr. LIGGINS said he was old enough to recollect old fashioned ships loading at the docks thirty years ago before proceeding on a voyage to Australia. At the present time the docks had been greatly enlarged. Ships of the finest class were now loading by the dozen, and being filled with manufactured goods after having, in the neighbouring import dock, discharged the products of the colony. He was sorry to say that, through the mismanagement of the Colonial-office, the colonies were being brought to ruin. Anything which would bring the colonies in closer contact with the mother country, would put wealth and prosperity in the hands of the working class, and do away with the large number of unemployed at present in England. He thanked Dr.

Mann most warmly for the able paper which he had placed before them that evening.

Mr. HYDE CLARKE said that, with regard to the debts of a country, it must not be forgotten that statistics were often misleading. It had been said that the debts of the colonies were overweighting them; that they were far beyond their fair proportion, and in the paper Dr. Mann had taken the figures from the usual sources, though it was scarcely possible to compare accurately the debts of various countries from common figures. In a country where the railways were constructed by private enterprise, if you took what was called the national debt, which had been raised for general purposes of war, and set it against the debt of a country where the debt had been raised for constructing railways, for instance, no adequate comparison could be drawn between the two. He had always been exceedingly anxious that statistics should not be pushed too far, for it was perfectly useless to add up figures which were incompatible, or to compare columns of figures which had no real relation. It had been represented, for instance, that New South Wales had carried raising of public loans too far, but the real truth was the contrary. Any colony which, so to speak, was in a desert had to provide itself with a national outfit, and consequently that outfit cost much more than it formerly did. Railways had now to be made, and the material obtained from abroad at great cost, whereas formerly roads were made by home labour, and the circumstances of the shipping trade had altered materially. Formerly it was sufficient, in many places, to run a ship into the natural ports, but now docks had to be constructed capable of taking enormous steamers. In fact, the whole appliance of civilisation and national outfit had increased. When these considerations were applied to the colonies, it would be found that they were making no undue demands; on the contrary they were doing their duty to themselves, and good to the people at home. The loans which had been raised for the colonies had, in most cases, been disbursed here, not like some foreign loans which were raised for war purposes, and disbursed in foreign countries. He was much indebted to Dr. Mann for calling attention to the American part of the question. There was often jealousy on the part of some of the colonies with regard to the United States, but it was impossible to consider the question of the colonies without introducing in their proper position the United States. They could not draw the line between the Dominion of Canada and the United States, as they were continuous for certain purposes. The States united the West Indies and Canada, and all North America belonged to the English-speaking community. Further, now that Canada and the United States touched the Pacific shore, they offered, by means of their Pacific railways, new routes to the Antipodes and a new bulwark to Australia. His own opinion was that England had suffered greatly by neglecting the United States, and by showing too much jealousy towards them, and that our future should be on a different policy.

Mr. S. S. BROMHEAD said he should be glad if Dr. Mann would inform them whether there was any great opening in Cape Colony for British capital.

The CHAIRMAN, in closing the discussion, said there was a great want of knowledge with regard to the colonial possessions, and any one who furnished information which was likely to dissipate that ignorance was a public benefactor, as it was very desirable that the people of England should know not only the geography of their own empire, but the colonial possessions of the mother country. That had been very clearly shown in the able compilation submitted to them that evening. With regard to the suggestion that at the forthcoming Exhibition a little map should be shown, giving information with regard to the products of the country, he could not exactly see how this was to be done; but he might say that pamphlets would be issued by all the colonies, containing information as to the resources of each, and attached to each pamphlet would be a small map. There was no doubt that the Exhibition would do an immense deal of good, as showing the raw products and manufactures of the colonies, and would be of more service than any system of advertising the colonies which had yet been adopted. There was a large field for emigration in Canada, as well as in Australia, for people of the right kind. It was no use to send out people who were not willing to work, and any scheme of emigration which contemplated the sending out of people indiscriminately to any colony would end in failure, and only remove the distress from one end of the world to the other. The vast progress which the colonies had made was indeed something for men to think of. People were apt to look upon Canada as the greatest colony, and in many ways it was, but when you compare the trade of Australia with that of Canada it would be seen that the trade of the Australian colonies was three times that of Canada, and the revenue of Australia was £22,000,000 as compared with the £7,000,000 of Canada. That would give some idea of the vast progress that had been made by the Australian colonies of late years. He fully agreed with the remarks that had been made as to the importance of the gold discovery, and Mr. William Charles Wentworth, at the time these discoveries were made, tersely said the effect would be to precipitate Australia into a nation. This prophecy had been carried out to the letter. In conclusion, he proposed a cordial vote of thanks to Dr. Mann.

Dr. MANN, in expressing his appreciation of the vote of thanks, said that the question asked by Mr. Bromhead would be more safely and efficiently answered by Sir C. Mills, the Agent-General for the Cape Colony, than it could possibly be by himself, and it was, therefore, better that it should be at once referred to him.

ELEVENTH ORDINARY MEETING.

Wednesday, February 19, 1886; Professor W. Grylls Adams, F.R.S., in the chair.

The following candidates were proposed for election as members of the Society:—

Bedford, Duke of, K.G., 81, Eaton-square, S.W.
Fletcher, Frederick W., 56, Hamilton-road, Highbury, N.
Forth, Henry, New Basford, Nottingham.
Knightley, Thomas Edward, 106, Cannon-street, E.C.
Peebles, Alexander, 23, Marlborough-road, St. John's-wood, N.W.
Spray, Henry John, 23, Arlington-square, N.

The following candidates were balloted for and duly elected members of the Society:—

Blades, Charles Mountain, Stanley Mount, Northwich, Cheshire.
Corry, John, J.P., Rosenheim, Park-hill-road, Croydon.
Plumbe, Rowland, 13, Fitzroy-square, W.
Thomason, Yeoville, 40, Bennett's-hill, Birmingham.

The paper read was—

SOME POINTS IN ELECTRICAL DISTRIBUTION.

By Professor George Forbes.

When I had the honour, just a year ago, to give a course of Cantor Lectures to this Society, on the distribution of electricity, the subject had not till then been treated in a systematic manner. I had then occasion to speak in strong terms of some of the methods habitually adopted, and subsequent experience has confirmed me in the justness of my criticisms. I gave a fairly complete account of the practical systems of laying electric mains which were at the disposal of the engineer when designing a system of distribution; but in the course of only three lectures it was impossible to do justice equally to all systems. When I was this year asked to read a paper before the Society, I eagerly availed myself of the opportunity to take up the straggling threads, and say a few words on the subjects which were previously but inadequately treated.

Allow me to remind you that, in my lectures, I described five different ways of laying the mains, each one depending upon a different method of connecting the dynamo machines and lamps. Three of these may be called direct systems, and two indirect. Each system has special advantages when applied in suitable cases, and when an engineer is designing a scheme of distribution he carefully considers the *pros* and *cons* of each system as applied to the special case, and very often he has to go through the whole calculations of the scheme according to several different systems. And here let me repeat, what I have often stated before, that no amount of labour and expense in these preliminary calculations should be grudged, as the ultimate saving effected by the careful selection of a suitable and economical system may easily range to 50 per cent. or more on the total cost of the installation.

The three direct systems are the parallel, series, and parallel-series methods of attaching lamps to the main conductors.* The two indirect systems are with the use of secondary batteries and secondary generators. Each of these systems is capable of being varied in the details of its application, and each is specially applicable to particular cases.

In a parallel system, each lamp is attached by wires to the two main conductors, and thus to the two terminals of the dynamo. This is its characteristic feature—viz., that the lamps are all metallically connected with the terminals of the machines.

In the series system, the conductor going through the district has its two ends connected one to each pole of the dynamo. But wherever there is a lamp the conductor is severed, and each terminal of the lamp is attached to one of the severed ends.

In the parallel-series arrangement the district is divided into sections. The first section and the last section have each a conductor attached to one terminal of the dynamo. The other conductor of the first section extends also through the second section but no farther. Another conductor extends through the second and third sections, another through the third and fourth, and so on. In each section the two wires from each lamp are attached to the two conductors of that section.

The first or parallel system is generally most suitable for small installations, but the cost of conductors becomes extravagant when the area is extended, except in very special cases. The series system is at present only used for arc lights, sometimes with the insertion of a few glow lamps in parallel to replace an arc lamp.

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* In my Cantor Lectures I used the terms multiple arc, series, and multiple series. I prefer the terms now advocated.

The third system is admirably suited in every case where the number of lamps in use at any time is constant, and may perhaps be modified so as to be applicable to other cases. Smaller conductors can be used on this system than on the first, and this effects a very great economy.

Having recalled these points to your notice, I need say no more, as I treated these three systems and their modifications very fully in my Cantor Lectures.

I thought I had spoken strongly enough about the enormous cost of the main conductors, and the necessity for selecting that size of conductor which is the most economical. We must not use too small a conductor, for then the waste of energy in heating the conductors would be enormous. Nor must we use too large a conductor, for this means buried capital. We must select that size which balances one cause of loss against the other so as to give the maximum economy.

I find, however, that, while this axiom has been accepted as such in this country, some writers from America still try to uphold the fallacious views which have hitherto been in vogue there. I have noticed more than one criticism from America, by people asserting themselves to be connected in some way with some of the Edison companies, who protest against my statement that the three-wire system effects an economy of copper of only 25 per cent. over a two-wire system. The difference between us is that I start with the *axiom* that we are to use the most economical size of conductor. My critics start with the *assumption* that they shall use a conductor which shall waste exactly 10 per cent. of the energy. In this way they use a conductor which is not the most economical, and they show a saving of 62½ per cent. of ccpper over the two-wire system, but with a possible extra waste of energy of 62½ per cent. I said in my Cantor Lectures, and I repeat it this evening, that this manipulation of figures may suit American financiers, but it is not electrical engineering.

Before proceeding to discuss the indirect methods of distributing electricity, which is the main point I wish to touch upon to-night, I wish to supplement my remarks on series lighting by a statement of what has been done in the last year. I expressed a hope that more attention might be given to the lighting of houses by glow lamps in series. I further showed that it was only by means of a constant current flowing through glow lamps in series that the regulation of each lamp could possibly be effected on economical principles. This regulation must be accomplished by altering the length of the filament in the lamp. This has never yet been done, but if inventors once realise the importance of the object to be attained, I feel sure that we shall not have long to wait for the solution of the problem. Now I am delighted to be able to inform you that during the past year at least one inventor has been applying himself to the placing of glow lamps in series. Mr. Bernstein, who has paid so much attention to the system of glow lamps, has worked out the problem of using lamps of low pressure and large current in series. He has boldly taken extreme measures, and proposes to use lamps of 6 volts and 10 ampères. And here he has got over a difficulty I referred to in my Cantor Lectures. I said that there was no economical way of preventing a broken lamp from extinguishing all the others on the series. Passing part of the current through a shunt whose resistance is 100 times that of the lamp would be very expensive if we had in use lamps of the ordinary type, but with a lamp whose resistance is a fraction of an ohm, the expense would be trifling. When the lamp breaks, the current in the shunt is increased so as to release a contact which short-circuits both the lamp and the shunt.

I still think, however, that the loss of energy by heat conduction at the terminals, may be very great in lamps of so low a resistance; Mr. Bernstein tells me it is 10 per cent. Still I can well foresee that, even if a very sensible loss of energy occurred, the economy and convenience of using such a system might be amply sufficient to warrant its adoption in many cases.

I congratulate Mr. Bernstein on his work in the past, and would urge him to develop this idea more fully, and I can assure him that I, for one, will give the fullest consideration to the system when preparing the plans for electric light installations.

I should like also to take this opportunity of congratulating other makers of electrical appliances on the advances which have been made since the date of my Cantor Lectures. I should like especially to congratulate Mr. Swan on the improvements he has made in the manufacture of glow lamps; the Messrs. Siemens and Messrs. Crompton on their successful construction of very large dynamos; Messrs. Elwell and Parker on their great improvements in the details of construction of dynamos and motors; and the Electrical Power and Storage Company on the continued improvements in their secondary batteries. I would equally congratulate Messrs. Willans and Crompton for the continued improvements in steam-engine governors, for keeping the current from a dynamo or the pressure at any point in the circuit constant; likewise Mr. Ferranti for having brought out an electric current meter which promises to fulfil all the wants of engineers and the public in this direction; and last, but by no means least, Messrs. Woodhouse and Rawson for various new devices which will go far to assist in designing and carrying out many schemes of lighting; and I would specially mention their automatic cut-out, adjustable to any strength of current, which, though not so new as some other devices, has only been brought prominently to my notice during the past year, and whose simplicity and reliability give me great confidence in employing it. I must not fail to include here, as a subject for congratulation, the rising esteem in which secondary generators are held, and the improvements which have been made in their manufacture.

When I add to this list the admirable lampholder of Mr. Alfred Swan, Varley's adjustable carbon resistances, and other small but useful accessories, I think you will agree with me that the facilities at the disposal of the engineer for designing a satisfactory scheme of electric lighting, and which have been added to his store during the past year, are very abundant.

About one of these appliances I should like to add a few words.

First, I may say that the Electric Lighting Act was rendered abortive, if for no other reason, simply for the want of an electric current meter which was in all points satisfactory. In the year 1882, a patent was taken out for a meter in which the current passing round an electro-magnet created a field where mercury was placed, which rotated when the current passed through the mercury from the centre to the exterior of the field. If the magnetism be proportional to the current, and the friction be proportional to the square of the velocity, then the number of turns completed in any time is a direct measure of the total quantity of electricity which has flowed through the meter in that time. The marked improvements introduced into this meter by Mr. Ferranti consist in the perfection of the magnetic circuit, and the introduction of an almost frictionless mechanism for correcting the revolutions and showing them on dials like a gas-meter.

I have many of these appliances on the table which any members of the audience may examine at the conclusion of the paper.

In referring to my Cantor Lectures, let me make a few remarks about a double Table which I introduced to assist engineers in calculating the size of mains required in any installation. These Tables have been copied into a number of technical journals and books of reference, but in nearly every case there is no word of explanation how to use them. I have found these Tables of such paramount convenience that I think it right to call attention to them once more. The economical size of main depends upon three variable factors—the price of laying down a ton of copper mains, the interest to be charged on the capital sunk in mains, and the value of an electrical horse-power for the number of hours that it is to be utilised during the year. My Table is divided into two parts. Look along the line in the second part which relates to the per-centage on capital which you propose to use, until you come to the column relating to that price of copper which you propose to use, and you then find a number printed which we may call the auxiliary number. Now take the first part of the Table and look along the line which relates to that value of a year-horse-power which you propose to use, until you find the auxiliary number; the heading of that column of figures tells you the size of main per 1,000 ampères which is most economical to use according to the data you have employed.

I will now remind you of the position in which we were left after a full discussion in the Cantor Lectures of the three direct systems of distribution. The parallel system, or the three-wire system, is admirably adapted in cases where the farthest lamp of the district is within two hundred yards of the central station. So soon as you go to greater distances the cost begins to increase in an alarming ratio. Hence this system would be applicable to a large district only by having engines and dynamos put down at a very large number of small stations. Now, a station is not worked economically unless the engine driver and stoker are fully employed, and the maximum economy cannot be reached with less than about 1,000 horse-power. Thus the parallel system is only applicable to cities so densely populated as to have a consumption of about 10,000 16-candle power lamps in a radius of two hundred yards. But in most districts of this class space is valuable, and a large number of such stations would be very expensive. We must then, in the parallel system of distribution, be content to work at a cost which is above that of the ideal of economy. There are many cases where the great simplicity of such a system does actually make it worth while to sacrifice this ideal of economy, and when an engineer is consulted on such matters, it is his duty to estimate the exact loss from not strictly following the ideal economical rules before adopting or rejecting this system. In order to make a parallel system effective, the central station must use distributing boxes, the methods of placing which are described in my Cantor Lectures.

The cure for all these evils would be found if a thoroughly satisfactory system on the parallel-series plan were known. In that case high tension electricity might be used involving smaller conductors. Thus the central station might be at a distance, where land is cheap, and it might be of any size, so that all the works would be in the same place, as they are in gas distribution. Here the only departure from the ideal of economy lies in the length of the conductors to the district which has the supply. But these conductors are comparatively small, and no engineer would recommend the adoption of such a system unless he found that the economy of having the works out of the expensive district counterbalanced the extra expense in mains.

Now I regret to be compelled to say that, after discussing all the ingenious plans on the parallel series system proposed by Mr. Edison and others, I arrived at the conclusion that at this time there is no parallel-series system of distribution which is quite satisfactory. I do not say that such a system cannot be devised, but I do say that at this moment no such system is available to the electrical engineer, except in the case where the same quantity of electrical energy is consumed in any district at all hours during which the current is being used. There are some cases where it will pay to insert equivalent resistances when lamps are put out. These cases are rare, but they must not be lost sight of by the engineer.

Having in the Cantor Lectures discussed all the direct systems of distribution, I will complete my outline of this part of the engineer's profession by an examination of the two indirect methods which I formerly touched upon only lightly, viz., secondary batteries and secondary generators.

SECONDARY BATTERIES.

During the electric boom (as Americans would call it) of 1882, the secondary battery took a prominent part, not so much for what it had done as from what was expected it would do. It was said that since no one would think of sending gas from the retorts without storing it in a gasholder, so the same must be done with electricity. Every one will admit that it is most desirable that this should be done, and I am glad to say that secondary batteries have been improved to such an extent that there is every reason to hope that this will be done, always provided that the companies who supply them do not expect the public to repay them for the hundreds of thousands of pounds which may have been thrown away in the past.

I have been given to test about a dozen different kinds of secondary batteries, of which I have found some four or five to be good, and the others mostly worthless. I can say this, that at the present moment secondary batteries can be supplied by certain makers which are to be relied on with careful usage, and which give us 70 to 80 per cent. return for the energy expended.

Now it might be asked what are the advantages of storing the energy if you lose 25 per cent. by doing so. The first advantage is that a breakdown in the machinery does not then interfere with the supply. The second advantage is that the steadiness of the supply does not depend upon the speed of moving machinery. The third and great economical advantage is that your expensive engines and dynamos are paying interest twenty-four hours of the day, instead of only a few hours, by doing their work; and a smaller supply of engines and dynamos suffices.

Now this is all very well, so far as having secondary batteries at the point of supply is concerned, but it does not help us much so far in the great problem which we have attacked, viz., that of electrical distribution. But the improvement of secondary batteries led to great hopes of a cheap system of distribution. It was said "Put your generating station at a distance, on cheap ground, carry a curren with high potential through light conductors to the district to be lighted. Pass the current through some thousand accumulators in series placing these in batches of fifty (say) each, in cellars, to light up a small district.'' The original idea was to keep the service wires permanently attached to the two ends of each set of fifty cells.

Now this plan is very beautiful if only it would work. But it will not work. The consumption being small from some of the cellars and large from others, and the same charging current going through all of them, the cells become overcharged in many cases, and this is injurious.

Another plan was proposed which I described in my Cantor Lectures. This was to introduce an arrangement to indicate when the cells were fully charged. By having two complete sets of batteries in each cellar, the indicator caused a rocking switch to act which switched the fully charged battery off from the charging mains on to the service mains, and at the same time switched the second set, which had, up to that time, been supplying the service mains, on to the charging mains. Here I would point out that, independently of the fact that we have no reliable indicator to show when the cells are fully charged, this only moves the difficulty back one step. For it will often happen that both sets are fully charged, and yet we are obliged to send current through one of them. This plan was tried at Colchester, but of course it had to be abandoned. If we had a true indicator to show when the cells are fully charged, the more sensible plan of using it seems to be to cause the indicator to disconnect the cells from the charging mains and connect the charging mains metallically. There would of course be a great fall of potential in lamps immediately after switching off the supply current, but the charging of the cells might be done by day or after midnight, during which time lamps are not very much used. I think that even this small difficulty might be got over by causing the indicator when it acts to increase the number of cells which lead to the lamps.

I suppose the most reliable indicators which could be used are those depending upon the specific gravity of the solution or the weight of the negative (oxydised) plate. Unfortunately, it is seldom found that a number of cells working in series become charged at the same time.

In fact, it is not very generally known that the most satisfactory plan for charging secondary batteries is to do so in quantity or parallel. When this is done, every cell is fully charged exactly at the same time, and all give off gas at the same moment. If there be any possibility of short-circuiting, however, fusible plugs or other cut-outs must be inserted.*

To have a thoroughly satisfactory installation, it is necessary that the cells may be left in their secluded retreats without attention for long periods. I think I can safely say that cells can be so left if fairly treated. But the question is whether any scheme of distribution hitherto considered does give them fair treatment. If attendants have to be continually going round to inspect cells, this expense must be carefully calculated so far as is possible, and taken into account.

Now let me say a few words as to the improvements in secondary batteries. First, I may say that there is now no doubt that they can be made, and are made, by several makers of so good a construction that they can be used for years. I will not fix the number of years, because none of the most perfect ones have yet failed. Secondly, it seems to be conclusively proved that not only does no buckling take place, but there is no fluting or blistering if the plates are originally good, and if the air has not been allowed to reach them. Thirdly, we know that in overcharging them we do not injure them, but merely waste current. These are important facts, and are all we want for an installation where the state of the cells can be always under examination. For central station lighting we want something more. We want the cells to take current from the dynamos when they require it. For this we must have an indicator on the cells to work a switch, accordiug to the state of charge of the current. Up to the present no satisfactory master-cell has been devised. Those which depend on the gas given off do not act equally promptly with currents of different strength. The most promising system is one in which the state of the cell is shown by the specific gravity of the liquid. Very little ingenuity is required to develop this into a satisfactory system. But we cannot depend upon one master-cell since it is only when charging in parallel that all cells act alike. If we have several master-cells in each battery, all of which must act together to cut off the dynamo, I think we might depend upon their action. The function of the switch is—first, when the E.M.F. of the battery is too high, to cut out the dynamo circuit from the battery, to give a through connection to the dynamo current, and to switch in two additional cells to the lamp circuit; second, when the E.M.F. of the battery is too low, to break the charging current, to connect the battery to it, and to cut off two cells from the lamp circuit. These are all ordinary things which can easily be done.

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* Even in this case we may have a partial short-circuit, which will drain the current and yet will not cut out the cell.

But even without automatic action of this sort there are many large installations where it would be economical to use secondary batteries even if attendants had to be continually examining the state of the cells. The engineer who is designing an installation, if he does his duty, calculates the cost of every method of working which can be feasible.

The cost is of course an important item, and were it not that this system introduces a great saving in copper conductors and machinery, it would often be too expensive to work. We may take the cost of batteries at about £3 per lamp of 60 watts. The saving in copper conductors is proportional to the number of batteries put in series. There is also a saving in dynamos and engines. If we take four hours as the average time of using the lamps, we charge them, say, for six hours in the day time, and we use the dynamos as well as the batteries during the greater part of the night. Thus we require batteries and dynamos for only about one-half of the number of lamps generally in use. This brings the cost of batteries down to £1 10s. per lamp, and the cost of dynamos and engines from about £1 per lamp (the usual cost for a direct service) to 10s. per lamp. This makes a total cost of £2 per lamp, as against £1 by a direct service. When we have made a further reduction for diminished size of conductors, and an increase for additional attendance, we are in a position to compare the two systems. But these figures vary so enormously that it is impossible to estimate them unless one has the details before him. We may say safely, however, that in large districts there is economy in secondary batteries, and in small districts in a direct service. But the advantage of not being dependent on the constant perfection of machinery is very great, and avoids the necessity for so complete a duplication of the parts. Of course the cost of working must also be made out, allowing for a loss of at least 20 per cent. in transforming through the secondary batteries.

The number of ways of using secondary batteries is great, but there are no engineering difficulties in the distribution, and I may, therefore, content myself with having drawn attention to the general advantages of using them.

Among the many special appliances used in this kind of work, I am glad to be able to show you some useful things supplied by the Electrical Power and Storage Company.

Perhaps the most important of these is a switch for large currents, in which a number of concentric tubes have a longitudinal slot into which the arm of the switch is forced. The split tubes have a certain amount of spring, and literally cut into the arm of the switch, and so make good metallic contact. The one before you has been thoroughly tested with 1,500 ampères passing through it.

Another appliance is an automatic switch to reduce the number of cells in the lamp circuit when the dynamo is charging the cells and *vice versâ*.

A third is a cut-out to prevent damage to the charging dynamo by an accidental falling off of speed. It has this peculiarity, that it puts the battery in circuit again so soon as the dynamo resumes its functions.

In concluding this part of my subject, I would draw your attention to the scheme of lighting the Vienna opera house. The dynamos are by Messrs. Crompton, of 72,000 watts each, and are driven by direct acting Willans and Robinson engines. I am told that they give an electrical horse-power for 3·7 lbs of coal. The secondary batteries are supplied by the Electrical Power and Storage Company. The three-wire system is adopted, 110 cells are ordinarily in use with each circuit, and 6 additional ones are available to keep the electric pressure constant.

SECONDARY GENERATORS.

I now come to speak of secondary generators, and since the principles which regulate their action are rather novel, it may be well if I spend a little more time in describing their action than I would otherwise do in a lecture treating chiefly of the manner of laying main conductors.

Everyone knows the principle of the induction coil. It consists of a core of iron surrounded by a coil of insulated wire called the primary coil, and by another one of insulated wire called the secondary coil. The secondary usually contains a larger number of turns and finer wire than the primary. The current in the primary is alternately made and broken by a simple automatic means. This magnetises and demagnetises the iron core. This is equivalent to introducing and withdrawing a magnet into and out of the secondary coil, and sets up currents in the secondary coil.

The electromotive force created in each turn of the secondary coil is measured by the number of magnetisations per second, and by the strength of the magnetisation. The latter is generally proportional to the number of turns in the primary, and to the current flowing through it. Thus the electromotive force in the secondary coil depends (1) on the number of turns in the primary; (2), on the number of turns in the secondary; (3), on the strength of current in the primary; and (4), on the number of makes and breaks in the primary current. Thus by having a large number of turns in the secondary coil, and a small number in the primary, a very high electromotive force can be obtained from a small battery connected with the primary.

If, on the other hand, a high tension interrupted current were sent through the fine wire coil we could get a large current from the thick wire coil.

Now, to feed a number of glow lamps in parallel, we require a large current, but this requires a large conductor. Here it was proposed to use a high tension alternate current (which acts just like an interrupted current) by a thin conductor from the works to the place of consumption, and there to transform it into a current of large quantity.

Then, again, another idea was thrown out. This was to carry the alternate current by a thin conductor round a large district, and at intervals to pass it through the first coil of induction coils, using the second coil to supply the lamps. Thus we should have a high tension current disconnected from the service conductors, and furnishing them all with a low tension current.

Induction coils used in this way have been called secondary generators or transformers. The perfection of manufacture of such apparatus consists in getting a maximum of induction and a minimum of heating. This has been admirably accomplished in the generators of Messrs. Goulard and Gibbs. Instead of wire, the coils are made of copper discs, or flat rings split at one point, and with ears projecting outwards at the split. These discs alternately belong to the primary and secondary circuit, and successive discs of each circuit have the ears soldered together in such an order as to make up a spiral. The iron core is, of course, made of iron.

Although the even discs belong to the primary and the odd ones to the secondary, it does not follow that alternate discs should be coupled together. We may couple the 1st, 5th, 9th, &c., together, and also the 3rd, 7th, 11th, &c., so as to form two secondary circuits, which may be combined in parallel. The number of possible modifications of this sort is very great.

When the primary coil is magnetising and demagnetising the iron core, the latter sets up a counter electromotive force in the coil, and thus the current is largely diminished. But when there is no external resistance in the secondary coil, that coil being short circuited, then any magnetisation and demagnetisation of the core starts a current in the secondary coil, opposite in direction to that in the primary and almost equal to it. Thus the iron cannot get much magnetised, for it is surrounded by two opposing currents almost equal in amount. In this case, therefore, the primary has little or no counter electromotive force opposing it, and consequently it flows more freely. This explains a thing which often puzzles the beginner, viz., that with a constant electromotive force in the dynamo the current in the primary is stronger when the secondary circuit is closed than when it is open.

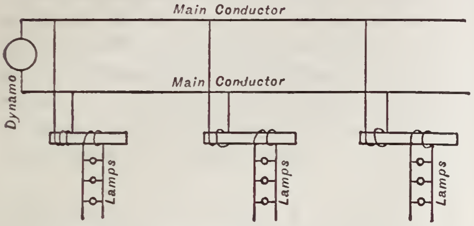
Very little energy is expended in magnetising and demagnetising iron wires. Thus there is really no loss of energy in the transformation, except that due to the heating of the conductors of which the coils are constructed, which is equal to the square of the current multiplied by the resistance. The loss of energy, which could not be accounted for, has been shown by Professor Ferraris to be less than 1 per cent., and the practical efficiency of the generator amounts to as much as 95 per cent.

The theory of the secondary generators is very like that of the alternate current dynamo, if the reversals of magnetism of the armature were given by reversing the currents in the field magnets instead of by mechanical motion.

Coming now to distribution by secondary generators we find we must use the same principles as in direct distribution.

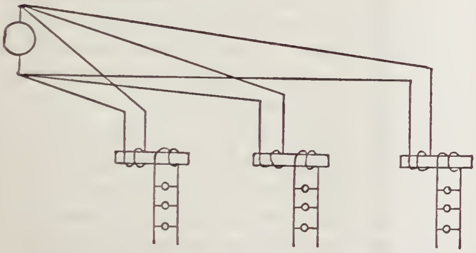
Parallel Distribution.—Let us take this case first. To do this economically we might lead two thin wires over the district and couple secondary generators to them. The condition of being able to have constant electric pressure in the lamps is that the electric pressure at the terminals of the primary should be constant. Here we meet the same difficulty as was experienced in direct supply. Consider three generators—1, 2, 3, Fig. 1. If the lamps are all on in all three cases, then the pressure for No. 3 is less than for No. 2, and that again is less than for No. 1. Suppose you try to rectify this by using lamps of lower pressure at the far station. In this case suppose the lamps in No. 2 are extinguished, then the pressure in No. 3 will go up and tend to injure the lamps. If you try to correct this at the central station you will lower the pressure of No. 1 till perhaps it only burns red. This difficulty is exactly the same as in the direct service. The remedy is of the same kind. You must use the generators as distributing boxes (see my Cantor Lectures, 1885), with separate wires from the engine to each generator, each one being fed with a different pressure from the engine house. Fig. 2 shows this arrangement. There is no objection to it except (1) that you must use a large number of conductors, and (2) you introduce the full pressure of the high tension current into each house.

FIG. 1.



SECONDARY GENERATORS IN PARALLEL.

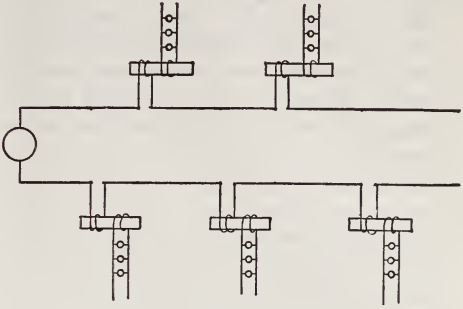
FIG. 2.



DISTRIBUTING BOXES REPLACED BY SECONDARY GENERATORS.

Finally, we come to distribution by generators in series. Here we have the best effect. A single wire (Fig. 3) goes round the circuit; if a double wire is used, to prevent affecting telephones, it is half the weight, and generators are alternately put on one wire and the other all round the district, and each pair of wires ends at a point far from the station. Suppose we use 10,000 volts, we may have 100 generators in series, each using 100 volts, or we may make any other arrangement. If it were done as I say, then following out the data of my Cantor Lectures, a wire of one square inch section will carry current enough for 100,000 lamps each consuming 60 watts.

FIG. 3.



SECONDARY GENERATORS IN SERIES.

In this arrangement we must send a constant current through the circuit. This is actually done by the introduction of resistances. It ought to be done either by an electric governor on the steam-engine, or by compound winding the alternate current machine, a matter about which there is no difficulty at all.

But how are we to attain to constant electric pressure in the lamps when we have got our constant current? This is a problem which has puzzled many people, and many have come to the conclusion that it is impossible to do it without mechanism. This used to be done by automatically introducing the iron core farther or less far into the coils. It is now done without any relative movement of the parts. This is the last triumph which has been added to a series of laborious experiments which year by year have brought us nearer to a solution of our difficulties. I am not at liberty to explain the *modus operandi*, but I have seen it at work, and it is very satisfactory.

The theory of secondary generators has been so little studied, except by specialists, that I have thought it might be advantageous to many if I added to this paper the formulæ which represent the electric current and pressure as depending upon the resistances and mutual induction of the various parts. These data will be found in an Appendix to the present paper.

I do not think it would be consistent with the objects of this paper to describe the specific differences between different kinds of secondary generators, or to attempt to give reasons for choosing one of these forms rather than another. I would merely draw attention to the brilliant experiments on self-induction by Professor Hughes, described in his introductory address as president to the Society of Telegraph Engineers and of Electricians. Professor Hughes has discovered a new and hitherto unnoticed source of waste of energy in self-induction, to remedy which it is essential to have the coils of the secondary generator made of discs.

I should also like, before leaving the subject, to dispel a growing error from the minds of some electricians. In speaking of different secondary generators, some persons are in the habit of speaking of one inventor's generator being used on a parallel system, another on a series system. This distinction is quite illusory. A generator made on any system is equally suitable for all kinds of distribution, and if an inventor states that his generator is only suited for one system of distribution he displays his ignorance, and shows that he has yet much to learn before he can say he understands the theory of secondary generators.

Last year, when speaking in my Cantor Lectures, I said that the Grosvenor Gallery installation would be followed with interest by engineers. I considered that it was a new test. Up to that time the method had been applied only to light districts where the number of lamps was constant. It was not proved that the method was suitable to the cases where lamps might at any moment be extinguished. Two things were necessary for this, (1) regulation of the current from the dynamo, and (2) automatic regulation of the electric pressure in the secondary circuit. Neither of these had then been accomplished in a manner which satisfied me, and I certainly considered it was a very bold step on the part of Sir Coutts Lindsay to adopt a system which was then so imperfect.

I am satisfied now that self-regulation of the secondary circuit is sufficiently perfect for practical purposes, even when the generators are in series; and I have pointed out to Messrs. Gaulard and Gibbs a further development which, in my opinion, will make their system even more perfect. The one weak point in the Grosvenor Gallery installation is the regulation of the current from the dynamo. Out of the four or five different methods by means of which this can be done, the worst has been applied up to this time, viz., hand-regulation. The result is a frequent flicker in the lights. Still, when we consider that seven miles of route has been covered by the wires of this small association, and that on the whole great satisfaction is expressed by the users of the light, I must say that Sir Coutts Lindsay and his friends are to be congratulated on the great steps they have made towards success.

In conclusion, I wish briefly to allude to the present condition of electric lighting, and the prospects of economical distribution from central stations.

I have always maintained that there were three causes which retarded the progress of electric lighting.—(1), financial speculation; (2), the Electric Lighting Act of 1882; and (3), the unsuitability of the schemes of electrical distribution propounded by the contractors. I will say a few words on each in turn.

From the year 1881 to 1883 this country was the scene of a most senseless speculation, started by clever men of business, who took advantage of the interest in electric lighting caused by the Paris and Crystal Palace Exhibitions, and supported by dupes whose ignorance of electrical matters was only equalled by their want of common sense as business men. These men combined to purchase for large sums the right to use the apparatus of some particular manufacturing firm in a special locality. They never asked any competent person whether this firm's apparatus was better or worse than that upon which there were no royalties to pay. Those who were not clever enough to get out of the affair before the bubble burst were the sufferers, and the consequence was a panic in connection with electric lighting which has hardly yet subsided.

With matured knowledge confidence is again being restored, because the public learn from competent and disinterested persons that economical electric lighting can be accomplished without the necessity for paying the heavy royalties formerly demanded.

I trust that the warning of 1882-3 will not be lost on financiers, and that they will not be misled by untried but tempting schemes unsupported by capable men of science.

The next cause which has deterred electric lighting is the Act of 1882. This is an Act to give undertakers the right to break up streets in order to lay conductors, under certain conditions. It is these conditions which are so unjust. Some of our legislators, looking at the monopolies which exist in gas supply, are afraid that electric lighters will raise another monopoly. Consequently, they determined to hamper the electric lighting industry with conditions different to those imposed upon gas, and more stringent. They succeeded well, for they laid down such conditions that no sane man would invest in such a speculation. You would have thought it natural, I doubt not, that if the gas monopoly was truly so very irksome, the encouragement of a rival illuminant would have been the best cure for the evil, whereas our legislators acted as if they were parties interested in maintaining the gas monopoly, for they imposed such restrictions as rendered it impossible for electricity to be supplied to the public. Let me name one of their wise provisions. At the end of 21 years the local authorities can, if they please, buy from the company supplying electricity the whole of their plant at the price of old material, without paying a farthing for goodwill or future profits, or past expenses in experimental and unprofitable work.

If then a company, after 21 years, were just making headway, and paying a dividend of 5 per cent. on their capital, the corporation would buy them up for perhaps a third of that capital, and get 15 per cent. But the case is even worse if the company is not yet earning a fair dividend, for then the corporation may hang over the company like a usurer over his victim, and each seven years it has the right to purchase the plant or not, and on the same terms as before.

Now, I agree with those who contend that electricity should be allowed to compete with gas under the same disabilities, and with the same advantages. This is not doubling a monopoly; it is splitting it into two, and destroying the monopoly, by allowing competition. If our legislators are not trying to uphold the gas monopoly, they must take this view. In any case the public have shown that they will not submit to be deprived by legislation of this illuminant. The Board of Trade, I hear, have perceived their error, and are prepared to yield a little; but if they do not enable us to have electricity supplied to us, we, the public, must force their hand.

Still electric lighting is not quite dependent on this Act. Local authorities have no penalties, and I would strongly urge them to take the matter up, for we have now arrived at a stage when it is safe and profitable to establish electric lighting on a large scale.

Again, you must remember that the disabilities of the Act apply only to those who lay their conductors underground and wish to break up the street. Sir Coutts Lindsay has taught us how to defy the Electric Lighting Act by passing the wires overhead. Those wires do not suffer like telegraph wires in snow storms, for the electric current melts the snow.

The third cause which deterred the progress of electric lighting, was the unsuitability of schemes of distribution which were proposed. I was impressed with this weak point at an early date. Sir William Thomson was the first to touch on the matter when he announced his law of the economical size of conductors. But the engineer had no Tables to guide him as to the safety of these sizes of conductors in the matter of heating. I attacked this problem first in order to clear the way for scientific methods of dealing with distribution. In a paper read before the Society of Telegraph Engineers and of Electricians, in 1883, I computed from the facts well known to physicists, the heating of different sized conductors with different currents, whether the conductors were bare, insulated, or buried. I had already, in a communication to the British Association in 1882, shown by experimental evidence, that the generally accepted laws required modification when we dealt with small wires.

The way being thus cleared, I attacked the problem of distribution generally, studying the various schemes which had been proposed or put in practice. My conclusions were published in the Cantor Lectures in 1885, and the most useful result was to announce a series of definite rules which must be attended to in order to provide an economical distribution. Since then some progress has been made, and the present paper will, I hope, bring the subject pretty well up to date.

The work which I undertook has been laborious, but it has been a very humble effort. I have brought forward hardly a single fact which could not have been foreseen by the competent engineer. But I think I have saved others from wasting their energy in repeating much of the work which is laborious; and I also trust that the outcome is a set of rules to guide those engineers whose purely scientific knowledge may be a little defective from falling into the gross errors which have been so apparent in nearly all attempts at lighting by electricity on a large scale which have been made in the past.

I now close the subject for a time, and if the labour I have bestowed upon it leads in any slight measure to establishing one department of electrical engineering on a sound scientific basis, I shall feel that in the work I have undertaken I have been of some little use to my generation.

APPENDIX.

The following formulæ give the currents and electromotive forces, on the assumption that the magnetism of the core varies as the sum of the currents in the two coils.

The E.M.F. of the dynamo is assumed as being—

$$E \sin. mt$$

Then the primary current $= I \sin. (mt + \gamma)$
secondary current $= I' \sin. (mt + \gamma')$

$$I^2 = E^2 \frac{C^2 + r'^2}{r^2 r'^2 + (r + r')^2 C}$$

$$I'^2 = E^2 \frac{C^2}{r^2 r'^2 + (r + r')^2 C^2}$$

Where C is a constant;
r = resistance of primary circuit;
r' = ,, secondary circuit.
Also the potentials at primary terminals $= v$;
and ,, ,, secondary terminals $= v'$;
where $v = V \sin. (mt + \phi)$
$v' = V \sin. (mt + \phi')$

$$V^2 = E^2 \frac{\rho^2 r'^2 + (\rho + r')^2 C^2}{r^2 r'^2 + (r + r')^2 C^3}$$

$$V'^2 = E^2 \frac{(r' + \rho')^2 C^2}{r^2 r'^2 + (r + r')^2 C^2}$$

ρ and ρ' being the resistances of the primary and secondary coils.

DISCUSSION.

Prof. HUGHES, F.R.S., said in his latest researches he had found that the maximum induction in iron took place when the iron was in the round form. If it was flattened, so that the contiguous portions of the current became separated from each other, the current was very weak; it had not one-tenth of its previous capacity. In the case of copper wire flattened, the reduction in the self-induction was about 50 per cent. Taking iron wire and passing a current through it, if you wished to have a secondary current parallel to it, the self-induction prevented the current acting on the secondary coil; in fact, the force of the electric current was used up in doing internal work. By flattening it, it re-acted on another wire to its full force, so that the energy which would have been used in self-induction, was transformed into the secondary current. He had not the slightest doubt that if this method were adopted, enormously more power could be obtained from the secondary coil. When two wires were flattened, the portions contiguous to each other did not re-act on each other with the same strength, but re-acted on any portion near; consequently, when there was another flattened sheet superposed, you had it in the nearest possible proximity. It was very remarkable that the same results at which he had arrived theoretically should have been worked out experimentally by Messrs. Gaulard and Gibbs, and they had arrived at the best possible conditions he could conceive for constructing a secondary coil. He had only one fault to find with it; the generator itself seemed perfect, but it required intermittent currents, and, therefore, it seemed to him there must be a loss in the line. He had been much interested in the paper, and hoped Professor Forbes would continue his investigations on this subject which he had made peculiarly his own.

Mr. GAULARD (who spoke in French) thanked Professor Forbes for his remarks upon the actual conditions and future prospects of the apparatus with which he was associated. He also thanked Professor Hughes for his expressions respecting the mode of construction adopted, and in answer to the objection as to the great loss caused by the use of alternate currents for leads of great length, he said he could rely upon the experiments made with their apparatus, and reassure Professor Hughes entirely on this subject. Their apparatus was constructed with two parallel circuits, forming spirals in the same direction. In order to obtain in the secondary circuit a variable electromotive force, they had contrived to unite in parallel and inverse directions the two circuits, and they had found that if in these conditions they sent through them an alternating current, the difference of potential at the ends of the spirals was directly proportioned to the resistance in the leads. If, on the other hand, they interposed in one of the connections a resistance, they found that the difference of potential at the two ends of the secondary circuit was, to a certain extent, directly proportioned to that resistance. From these observations it followed that if the leads consist of two parallel wires, and currents in opposite directions are sent through, not only no phenomenon of induction on the outer external circuit can appear, but no self-induction on these two leads can exist any more. As a practical demonstration of these results he quoted the experiments made in 1884, near Turin, on a line of 80 kilometres, which the kindness of the Telegraph Administrators of the Government had allowed them to establish on their telegraph poles. By reason of the limited space, the two wires (out and home) were placed at a distance of

15 centimetres from each other, and at the same distance from the telegraph wires. When properly insulated, the telegraph engineers ascertained that their apparatus had not been affected by any induction, and the jury, in determining the loss by the resistance in the leads, likewise ascertained that this loss was equal to the produce of the square of the intensity of the current in the lead by its own resistance.

Mr. KAPP said he did not know much about the distribution of electricity, but he should like to add one more to the list of improvements which had been placed at the service of the electrical engineer, and that was the reduction which had been made in the speed of the dynamo. If electricity were to be distributed for domestic use, you must be quite sure that there should be no breakdown; that was an imperative necessity, and the best way to ensure that was not to drive the machine at too high a rate of speed. Within the last few years the tendency had been to reduce the speed of dynamos by designing them in a more scientific way, making use of stronger fields, and of altogether better mechanical construction. Machines were now running at half the speed of those constructed a few years ago, and in this way the chances of failure were enormously reduced.

Mr. B. DRAKE remarked that Professor Forbes had drawn attention to the different ways in which electricity might be distributed for lighting purposes, but had not fully compared the relative advantages and disadvantages of the different systems. On behalf of secondary batteries, he would claim advantage in the practical impossibility of totally extinguishing a district through the failure of a single wire. No doubt there were many points which might be claimed on behalf of secondary generators, such as the first cost being less, and there being stronger metals in use which would be likely to last longer than lead plates, but at the same time the contingency of a station being extinguished all at once was an important consideration, and the fact of the engine having to be run to its full power whenever all the lights were required would more than balance the small extra cost of the accumulators in the first instance. The question had been raised as to the different details of apparatus necessary in connection with secondary batteries; they had been experimenting with every kind of apparatus for the last 18 months, with a view to ascertain how far it was really worth while to complicate the system by putting in automatic contrivances, and after designing all sorts of apparatus, they had come to the conclusion that the whole thing ought to be kept as simple as possible. For instance, Professor Forbes had referred to an apparatus by which, when the dynamo started charging, the number of cells in circuit might be reduced. That was a very easy mechanical problem to solve, and such an apparatus had been made; it was designed specially for train lighting, where an accumulator was to be placed in each carriage and charged in series, so that a train might be split up without difficulty, and accumulators charged in this way would really be a model of what was required on a larger scale for district lighting. Then they had to face the question of cutting off an extra cell as soon as the dynamo was put into the circuit; but it was found that the question of the accumulators being either fully charged or practically empty made so much difference to the electromotive force between the terminals, that to cut off any fixed number of cells was practically barely worth the trouble. When a cell was practically empty, you required only 2·2 volts. to charge it with a certain current, whereas to get the same current through it when the cell was full required over 2·5; the cutting off of a definite number of cells was therefore practically not worth the cost of the apparatus. It was, however, found advisable to introduce some kind of automatic switch in any installation where the attendant ever had to leave the engine. There was again the question of the regularity of the light. If the engine power varied at all where secondary generators were used, that variation was transmitted throughout the whole district; if a bearing ran hot, all the lights felt it; and in addition to that, there was the variation which Professor Forbes now said had been nearly overcome, which was due to varied consumption at different points of the circuit. With secondary batteries none of these evils occurred, and if some apparatus could be made reliable for cutting them in and out when fully charged, it seemed to him the solution of the problem would be complete. He agreed with Professor Forbes that the specific gravity was the right principle to adopt in cutting out the accumulators, and that the master cell system would be much improved by having two master cells which would have to be completed before the automatic cut-out would work. The difficulty with the specific gravity apparatus was this. The carrier which carried the whole apparatus had to float as well as the hydrometer, and in order to do that, the cell containing it had to be enlarged. In that way the bulk of the acid was enlarged, and consequently, the range in specific gravity became so extremely small, that you could practically do nothing with the small variation of the hydrometer. On the other hand, with the extremely small space which was necessary to get any appreciable variation, you had to employ such a small apparatus, that you could hardly rely on its working properly. The only way to get any results was by a system of relays, and that was difficult near accumulators, because the contacts got corroded by the acid. No doubt the advocates of the other system would be able to point out objections to secondary batteries, and he should be much interested in hearing them.

Mr. SHOOLBRED said it had been stated that the difficulty of knowing the state in which secondary batteries were, when they were fully charged, and when they were getting exhausted, had been got over by the use of hydrometers. He should like to know if this had proved really successful.

Mr. DRAKE said he had just been explaining that the great difficulty was the confined space. He did not know of any case where they had been used practically for actuating switches automatically.

Mr. MORDEY thought the carbon resistance guage shown was very similar to that which had been made for years by the Brush Corporation, consisting of a series of small carbon plates in a case, with a screw or lever arrangement to enable the resistance to be varied by alteration in the pressure. The principle had been used by Mr. Brush in his automatic regulator. The origiual principle he believed was due to M. Clerat, who communicated it to Professor Hughes in 1867. With regard to lamps of low resistance, he might say that on some circuits at Eastbourne and also at Brighton, the plan had been in operation, not with so low a resistance as Mr. Bernstein used, but so low as to allow of three lamps in a group being used, instead of eight or nine; each lamp taking a current of 3·3 ampères, the normal working current being 10 ampères. The manipulation of a group of lamps was very much simplified when the number was reduced; and if it could be reduced to one, and a constant current could be maintained through the circuit, the perfection of simplification would be attained; but even where three had been used in a group, with about 15 volts at the terminals, the manipulation of each group was not a serious matter. Where people employed a large number of lights, they might object to turn out eight or ten, but the same objection did not apply to a group of three. He should like to ask if there was any advantage in using secondary generators in the manner shown in the diagram in parallel; it seemed to him that all the effect thus obtained could be obtained much better by the ordinary direct supply. The cost of leads and the whole of the problems connected with the question would be much the same in each case. Another point in connection with secondary batteries was of great scientific interest, and that was as to the actual loss of energy in the iron of the core due to the rapid magnetisation and demagnetisation. There had been a great deal of discussion of late years as to whether any energy was really lost in this way, and it was a very difficult subject to work at, because it was almost impossible to eliminate the effect due to eddy currents, and that due to the turning over of the molecules, as Professor Hughes would call it. In an ordinary dynamo machine, where the reversal of polarity was not so rapid, only 400 or 500 revolutions a minute, and the molecules only required to be tured over 800 or 1,000 times a minute, the difficulty was not felt, but in secondary generator coils, where the reversal of magnetism took place thousands of times in a minute, it would be very different, and he should like to know if the actual loss had been ascertained.

Mr. GAULARD, in answer to the observations of Mr. Drake respecting the great loss which might result from the retardation in the molecular vibrations, produced by a very great number of alternations—an opinion based upon certain facts observed in the use of a current having 1,000 alternations per minute—he would point out again that, in the experiments made by the international jury of Turin upon the secondary generators by the most exact method, the calorimetric method, the current used had 16,000 alternations per minute; the yield had been proved to be 95 per cent. This is the greatest number of alternations obtained till now, by an alternate current machine of the largest type known, and perfectly sufficient, he thought, for producing the highest electromotive force which may be wanted from a practical point of view.

The CHAIRMAN drew attention to the several points which had been raised by Prof. Forbes, and which had been brought out in the discussion, such as the relation of the size of conductor to the mode of distribution, and especially the part played by secondary batteries, and, again, the important applications of secondary generators so ably explained by M. Gaulard. Now that electric lighting was not going forward with such hot haste as it was two or three years ago, those who were connected with it had more time to think about the best and most efficient methods of doing the work, and the lull would be found to be a time of great profit to electric lighting. We may be thankful to Professor Forbes for making the question of the size and arrangement of conductors so much his own, and for giving us the benefit of his researches in this direction. We must also thank him for so ably bringing before us in the Cantor Lectures, and in his paper this evening, the results of a great deal of thought and experiment on the different systems of lighting. Thanks to his and other researches, we may say that electric lighting is on a much more stable basis than it was three years ago. When it was stated that you could depend on getting out of storage batteries 70 or 80 per cent. of the energy employed, it was evident that a great step had been made during the last three years. Coming to the question of secondary generators, a very successful experiment had been made—indeed, it was almost more than an experiment—by Sir Coutts Lindsay. He might also refer to the experiment made some time ago by Messrs. Gaulard and Gibbs, in which they lighted up part of the Metropolitan Railway—from the Edgware-road-station to Aldgate in one direction, and Notting-hill-gate in the other—from one central station. The apparatus exhibited this evening showed that even then they had made very great progress, and that they had gone far ahead of the position to which they had then attained.

Professor FORBES, in reply, said some of the points raised had been already answered. M. Gaulard had replied to Professor Hughes by telling him of the effect of the double line; and he would observe that in doubling the line it was not necessary to double the quantity of metal, because, as shown in the sketch of the series arrangement, when you doubled the line, you tapped both wires, and therefore made the wires half the section they would otherwise have been. He ought to have congratulated Mr. Kapp on the improvements he had effected, but he should congratulate him on increasing his magnetic induction and the capacity of his machine, more than on diminishing its speed. It was perfectly true there might be less chance of failure in a machine when running at half speed than at the speed it used to run, but at what a tremendous cost that safety was obtained. The machine ought to do double the amount of work it did at that reduced speed. When there was a central station to light, the dynamo must be run at a reduced speed, but it must be made up for in another way by increasing the size. When there were large districts to light, it would be economical to have large machines going at comparatively slow speeds. When Mr. Drake came to look at the paper, he thought he would find that he had given full credit to the advantage he had mentioned of a district never being put in darkness through one wire breaking. He was sorry to hear that the sum total of eighteen months work was, that they could not leave the batteries alone to automatic appliances to work themselves, and he trusted that Mr. Drake would reconsider that question. He hoped to see secondary batteries largely used in central station-lighting, but if it involved the necessity of attendants going round to look after them and switch them in and out, it would be a serious drawback to their introduction. He ought to have mentioned that it was Mr. Drake who originally suggested to him the use of two master cells. He could not give Mr. Shoolbred any more information with regard to the use of hydrometers than Mr. Drake had furnished. In reply to Mr. Mordey, of course he did not mean to say that the use of carbon plates as an adjustable resistance was new, but he drew attention to this instrument of Mr. Varley's because he believed it was new, and it possessed advantages he had not seen in any previous arrangement. It was perfectly adjustable by the screw, and did not require knocking on the table to shake the pieces apart, as he had found with Mr. Brush's apparatus. With regard to the advantage of using secondary generators in parallel, he would point out that if the station were at a great distance, very thin conductors might be used to the generators. You might use a primary circuit of any series, and take as the secondary coil a number of discs in parallel, and so use a high tension current, thousands of volts in the primary, and yet have only 100, or whatever was required, in the house, and have all the economy of thin conductors. With regard to the loss of energy in magnetising and demagnetising, he agreed with M. Gaulard that it was an extremely minute quantity which could not be detected; the loss when a core of iron wire was used was very small indeed.

The CHAIRMAN then proposed a vote of thanks to Professor Forbes, which was carried unanimously.

Miscellaneous.

COLONIAL AND INDIAN EXHIBITION.

From the very nature of this Exhibition, it was evident to its promoters that ample time would be needed for its organisation. On the 24th of November, 1884, H.R.H. the Prince of Wales—who took upon himself the Executive Presidentship of the Royal Commission, which had been gazetted on the 18th of that month, and which consists of 120 noblemen and gentlemen—issued an invitation to India, to Canada, and to the whole of the British Colonies to come forward, and, by participation in the Exhibition, to give to the inhabitants of the British Isles, to foreigners, and to one another, practical demonstration of the wealth and industry of the British Empire.

The hearty response which was given to his Royal Highness's appeal shows the wide-spread interest in Imperial affairs which exists throughout the colonies, and argues well for the success of the Exhibition. With but few exceptions (*e.g.*, Newfoundland, Tasmania, Heligoland and Gibraltar), the whole of the British Colonies will contribute their share towards the Exhibition, which is to be opened early in May.

The remoteness of many of the colonies obviously precluded protracted correspondence. The Royal Commission, therefore, allotted at the outset to each colony that portion of the buildings which appeared most suitable to its requirements. By the kind permission of Sir Philip Cunliffe-Owen, the Secretary to the Royal Commission, a copy of the plan of the Exhibition is issued as a supplement to to-day's *Journal*. But few words will be needed to render this plan readily understood; and to those who are familiar with the buildings at South Kensington, it will perhaps be not impossible to picture in fancy the courts of the Colonial and Indian Exhibition of 1886.

The whole of the South Galleries are devoted to India and Ceylon; while the Dominion of Canada will be located in the Central Gallery and part of the Eastern Gallery. Between them is situated the Australian Courts, subdivided amongst the five divisions of the island continent, flanked on the west by New Zealand, and on the east by the West Indies, which are placed in the southern halves of the Western and Eastern Galleries, respectively. Between the West Indies and Queensland lie Malta and Cyprus; and to the north are British Guiana and Hong Kong, which appropriately finds a place in the old Chinese Court. In the Queen's-gate Annexe will be found representations of all that belongs to England in Africa—the Cape of Good Hope, Natal, the Gold Coast, Lagos and the West Africa settlements; while the remaining smaller colonies have been placed in the Eastern Arcade.

The structural alterations which circumstances have rendered necessary are few in comparison with those caused by the last two Exhibitions. The principal are the addition of the Central Annexe, which affords more space to Australia, and the South Annexe, which has been erected to meet the requirements of the Indian Commission.

Every week now sees ships entering the port of London, bearing freight from distant colonies destined for the Exhibition.

Every colony has now appointed its Executive Commissioner,* and many of them are now actively superintending the preparation of their courts. Amongst recent arrivals are the Honourable Malcolm Fraser, Executive Commissioner for Western Australia; Mr. Thomson, the Secretary to the Victorian Commission; Mr. Cowper, Secretary to the Cape of Good Hope Commission; and Mr. Trevenen, the Assistant Commissioner for the Straits Settlements. When it is mentioned that the High Commissioner represents the Dominion of Canada, and that the Agents-General perform a like function for their colonies, sufficient guarantee has been given that the result will be worthy of the occasion, and that the force of the Exhibition's motto, *Cor unum, via una*, will be fully realised.

A glance at the record of attendances at last year's Exhibition is sufficient to show that directly the fine weather broke up and gave way to wet and cold, the visitors grew fewer. This may, probably, in some measure be attributed to the fact that most of the visitors—who came more for the sake of listening to the bands in the gardens than for studying machinery of a complex character—found that, when driven indoors by stress of weather, there was no promenade of sufficient width to render locomotion agreeable. This consideration has led the authorities to leave a broad promenade—twenty-three feet in width—straight down the Middle Court of the Southern Galleries. On each side of the path will be a series of elaborately carved screens contributed by the principal provinces and native States of India; and if those which are to come fulfil the earnest which is given by those already erected, this Indian Avenue will be one of the most remarkable features of the Exhibition. Mention must specially be made of a splendid screen from Baroda, which is most pleasing in architectural design and rich in carved detail. Across the eastern end of this gallery will run a fine screen from Jeypore, surmounted by a small kiosk. Under each screen, the visitor will be able to enter into a small court allotted to the particular province or State: and he will then be able to study the wealth of India, from its gold and silver ware of rich tracery, its pottery, beautiful alike in colour and form, and its silks of wondrous softness, to the instructive, albeit somewhat dull, raw products which will be placed in the South Court. Here the latest of Britain's acquisitions will be represented; and amongst other exhibits will be seen large logs of teak sent by the Bombay and Burma Trading Corporation which played a not unimportant part in the causes which led to the annexation of Theebaw's dominion. Not the least attractive feature in the Indian Court will be a jungle scene, which will be placed in the north-east corner, and which owes its origin to the liberality of the Maharajah of Kuch Behar. Plants, grasses, and reeds have been forwarded from India, together with the necessary skins, which are being prepared by Mr. Rowland Ward. The main incident will be the attack on an elephant by several tigers, while in another portion of the jungle will be grouped smaller animals and birds.

To the north of the Indian Court, and on the site of the old Royal Pavilion, is being erected an Indian Palace, in the forecourt of which there will be a bazaar, wherein native artificers will follow their respective trades. The entrance to the Palace will be through a carved stone gateway from Gwalior, which the Maharajah Scindia has recently presented to the South Kensington Museum, and which is being erected in strange *vis-a-vis* to the Bishop's Gate of "Old London."

The Indian Court is more advanced at present than any of the colonies, and the remaining space at disposal will only permit a short account of a few of the many attractive features which may be expected from the colonies.

There are to be a wonderful trophy of gold nuggets, a fern gully and an aviary with birds of brilliant plumage from Victoria; orchids of wondrous growth, and diamonds of marvellous size from the Cape; of a native house with native inhabitants just arrived from Singapore; and of a family of weavers from Cyprus. The Valetta Gateway at Malta will be reproduced as the entrance to the Maltese Court; and the Aquarium will possess additional interest from the fact that it will contain Indian and Canadian fishes, which will visit these isles alive—many of them for the first time; nor will the turtle from the West Indies be wanting.

After the ceaseless whirl of last year's Exhibition, there will be a marked absence of machinery—as, with but slight exceptions, Canada alone will show machinery in motion. This is, doubtless, due partly to the great expense which the transport of heavy machinery would have entailed, and partly to the fact that the colonies still trust, in great measure, to the mother country to make finished articles of their raw produce. Above the southern entrance to the Central Annexe will be placed a large coloured map of the two hemispheres, on which the various countries which make up the British Empire will be prominently marked; the map will be surmounted by a series of five clock faces, which will simultaneously proclaim the time at Greenwich, Calcutta, Ottawa, Sydney and Cape Town—overtopped by a colossal figure of Britannia.

As the visitor arrives at the main entrance at Prince's-gate, he will find himself in the vestibule, on whose walls he will see representations of colonial cities, surmounting carefully-prepared statistics of population, area and other matters. Round the statue of H.R.H. the Prince of Wales will be grouped models of ships trading between England and her dependencies across the seas.

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* A list will be found above the plan issued as a supplement to this number.

Cases and pedestals of native woods and stones may be expected from those colonies which possess trees and quarries suitable for the purpose.

The colonial frozen meats and Indian and Colonial fruits and vegetables will not be forgotten, and arrangements have been made by the Royal Commission for the due representation of Indian and Colonial produce of all kind. The Royal Albert Hall will again form a part of the Exhibition, and advantage will be taken of its cellars to place in them wines which New South Wales, Victoria and the Cape are sending over; and in the gallery will be hung pictures of all kinds painted by *bonâ fide* British colonists, together with pictures representing objects bearing on colonial history, and portraits of colonial and Indian celebrities, notably those of several of the Rajahs.

The supply of motive power for the internal lighting of the Exhibition has been, as at the three former Exhibitions, entrusted to Messrs. Davey, Paxman and Co., of Colchester, while the actual lighting of the buildings has been placed in the hands of five well-known firms. Messrs. Galloway and Sons, of Manchester, take the place of Messrs. Siemens Brothers as contractors for the garden lighting. Sir Francis Bolton will again preside, from the clock tower, over the fountains, from which novel features may be expected.

On entering the buildings in the evening, one will miss the myriads of little star-like lamps which formerly met the gaze in the southern galleries, and will find in their place fewer but more powerful arc lamps. The whole of the electric lighting is under the superintendence of a committee, appointed by the Executive President, of which Sir Frederick Abel is chairman.

A novel feature in this year's Exhibition will be the presence of hundreds of flags suspended from the roofs of the different galleries, and bearing on them the badges of the colonies in whose courts they hang.

As in the case of previous Exhibitions, a guarantee fund has been raised to meet preliminary expenses, and it is highly satisfactory to think that so deep an interest is taken in the Exhibition, that this fund has now reached upwards of £200,000. This is, in some degree, doubtless due to the fact that hitherto these guarantees have resulted in nothing more than the signing of a form.

It was felt at the outset that it would be impossible to draw up a classification that would either embrace or do justice to the very varied products of the different colonies; and it was therefore decided to allow every Colonial Commission to prepare a classification best suited to its own requirements. This same feeling—together with the consideration (as expressed by H.R.H. the Executive President at the first meeting of the Royal Commission) "That, as some colonies from their age and circumstances were more advanced than others, those in their infancy should not be placed at an undue disadvantage in an Exhibition from which all thoughts of trade rivalry should be excluded"—doubtless suggested the abandonment of the jury system of former years, which will be replaced by a series of reports prepared by experts. Each colony will, if it wish it, publish a catalogue of the exhibits in its own court; but the Royal Commission will issue a general catalogue of the whole Exhibition; and, moreover, a general handbook of the British Indian and Colonial empire, with special reference to the objects in the Exhibition, will be published at a comparatively low price. Conferences also will be held on matters of colonial importance.

Following an idea which was carried out during 1851 in connection with the Great Exhibition, a scheme of workmen's clubs has been inaugurated throughout the United Kingdom. The mayors and principal authorities of nearly all the large towns have expressed their willingness to co-operate with H.R.H. the Executive President, with a view to affording to artisans and workpeople, as well as to their wives and families, an opportunity during the present year of visiting the Exhibition, as much for the purposes of instruction as for those of entertainment. In many towns steps are being taken to establish clubs, to which during the earlier months of the year workpeople will periodically subscribe small sums. At any time which may be convenient to them after the 21st June next, the members of such clubs will be able to withdraw their subscriptions (which in certain cases will be aided by grants from sympathetic donors) and will be able to proceed, with members of their families, to London for one or more days: but in no case can the stay in the metropolis, under the terms of club membership, exceed twelve days. The proprietors of all respectable hotels, lodging-houses, &c., who may be disposed to offer accommodation to the classes indicated, are requested to send in—not later than the 30th April—a statement, to the Official Agent of the Royal Commission, at the City offices, 96, London-wall, London, E.C., specifying in detail the sum they will be prepared to charge per head for bed, breakfast, dinner, and tea or supper for adults and for children, for one or more days, not exceeding twelve. After due inquiries have been made as to the respectability of applicants, their names and addresses, and the rates they propose to charge will be printed in a list which will be supplied to all local clubs. The applicants will be deemed to agree to make only such charges as are indicated in their letter of application. Any complaints made to the Royal Commission by visitors will be inquired into; and, if they prove to be well founded, the names of those persons who have given grounds for such complaints will be removed from the list, with an intimation of the reasons for such a course of procedure. Each member of a club will be supplied with a ticket, properly indorsed by the Exhibition and the local authorities, as a means of identification, and as a proof of his right to the special terms indicated on the lists supplied to the clubs. The Royal Commission limits its responsibility to all parties to the action above described.

At this early date, it is obviously impossible to do more than allude in the most general terms to the nature of the displays which may be expected to meet the eyes of visitors in May, and to treat otherwise than in a most superficial manner the arrangements which are in course of organisation for the instruction and amusement of visitors. But it is proposed, from time to time, to point out more in detail some of the important features of the coming Exhibition.

INQUESTS ON FIRES.

The following extract from a communication on the subject of fire inquests, which has recently been addressed by Captain Shaw, Captain of the Metropolitan Fire Brigade, to the Gas and Water Committee of the Corporation, is taken from the *Times* :—

"The question of official investigation into the causes of fires arises periodically in England, but nothing is ever done with it; a few articles appear in the newspapers, and there the matter ends. The fact is that investigations cost money, and that heavily-taxed communities are unwilling to increase their expenses. They seem to prefer an occasional growl against some imaginary authority (really themselves) to a payment in cash to an actual rate collector; and, taking all the circumstances into consideration, is it quite possible that they may not be altogether wrong. Certainly an increase of paid officials, merely for the purpose of investigating the causes of fire, without in any way reducing the material losses resulting from it, would be a serious matter, unless, as some affirm, not without reason, the existence of such officials would itself act as a deterrent to the fraudulent or criminal, and as a stimulant to the negligent or thoughtless. As it is, almost everything is left to chance; no public official hss the right even to investigate beyond a certain point, and doubtless many criminals escape. Something, however, is done. The Fire Brigade officer in charge, before leaving the scene makes every possible inquiry in order to discover the circumstances that led to the fire, but the result is in many cases without effect, the number of fires in London for which a cause can with any certainty be assigned being only about 80 per cent. of the total number, leaving some 20 per cent. unaccounted for. Many have recommended that a strict investigation should be made by responsible officials having power to examine witnesses on oath; but a careful consideration of the subject will show that the universal adoption of such a course would be surrounded by many difficulties. The time occupied in these inquiries and the consequent expense would be simply enormous, and the money might perhaps be more profitably laid out on stations, firemen, engines, and extinguishing appliances of every kind. The constant trials would absorb the whole time of all concerned, both sufferers and firemen, and would occasion an almost complete stoppage of their business. Perhaps it ought to be explained that the term 'sufferer' is applied by firemen to the owner of property damaged or destroyed by fire, and the term 'customer' to those who have had more than one fire. There are undoubtedly many members of every community whose private business would not bear the light of an official inquiry. The persons concerned might be perfectly innocent of any unlawful action in connection with the fire, but they might all the same be irretrievably ruined by the exposure of their affairs. The curiosity aroused might also prove disagreeable, and there would be great danger of such inquiries being made use of for the pecuniary ends of those commercially interested in opposition—in short, their rivals in trade. Many would take such an opportunity for bringing forward any unpleasant circumstances concerning the career of the sufferer, and, under cover of giving evidence, of spreading slanderous reports. In the City of London and the borough of Southwark in 1845 special fire inquests were held by the coroner on the causes of all fires which were thought to be doubtful in their origin. These inquiries were carried on until the beginning of the year 1850, and were then discontinued, as it was found by the authorities that the amount of money expended far exceeded the importance of the results, and there was understood to be some doubt as to the strict legality of the proceedings, or of the payments rendered necessary by them. It was said at the time that although perhaps inquests might legally be held, there was no fund out of which the expenses could be paid except in the event of loss of life. From the year 1845 to 1850, 71 fire inquests were held, with the result that nine fires were found to have been wilfully caused, 34 to have been accidental, and in 28 cases no conclusion at all could be arrived at. In four out of the nine cases the persons implicated were prosecuted; but out of the four there was only one conviction. All who have ever studied the subject have given their opinion that a power of some kind should exist for holding investigations concerning the origin and circumstances of fires; but no satisfactory solution of the difficulties surrounding the question has been proposed. An investigation into every case would prove an unmitigated nuisance, and involve prodigious expense. Taking, for instance, London, with over 2,000 fires in the year, and allowing the very moderate cost of £50 for each investigation, there would be an annual expenditure of more than

£100,000, which nearly equals that of the existing brigade. But, on the other hand, if an investigation is not to take place concerning every fire, where should the line be drawn? Should an authority be appointed to decide as to the necessity for investigating special cases? Should this authority be a Court, a jury, an individual, or a consulting committee of police, firemen, and others? And, in the event of its being a Court, should it be a fixed or a movable Court? What should be the result of their action in the event of their deciding that an investigation should be held? What, in the event of this decision being acted on, and proving to have caused damage to an innocent person? And, lastly, should any limit be imposed on the power of the Court to compel warehouse keepers, dock owners, wharfingers, and other agents to disclose the affairs of their customers? These are only a few of the formidable difficulties which seem to have overwhelmed every one who has hitherto attempted to deal with the subject of investigation. Probably the simplest solution of the matter would be to appoint a salvage corps, with a recognised authority, in conjunction either with the Fire Brigade or the police; but the expense of such an arangement would also be appreciable, and the service rendered would be on behalf not of the ratepayers who pay for it, but more frequently of the persons who, whether innocently or not, cause the fires. It may seem strange that such a city as London should never have had a salvage corps; but when it is remembered that in the event of a fire there are at present several forces working independently, it will be seen that those who have had experience would naturally hesitate to add another. There are now the police, the water companies, the insurance companies' private salvage corps, and the Fire Brigade, and the addition of a public salvage corps might only cause confusion; but there can be no doubt that the time is coming when it will be absolutely necessary that some arrangement shall be made for the enormous quantity of uninsured property, which is stated by the insurance companies to amount to four-fifths of the whole, although other authorities estimate it only at one-half. But, whatever the proportion may be, there can be no doubt that the value of uninsured property in such a city as London is enormous, and that there ought to be some recognised body intrusted with the duty of guarding and otherwise protecting it during and after fires, and with the power of investigating all circumstances connected with fire."

TRAMWAY STATISTICS.

A report is given in the *Economiste Français* of the 9th January last, of a speech on the development of tramways, delivered by M. Clermont, Director-General of the Railways of Liege-Maestricht, at a meeting of the Engineers' Association of Gand. M. Clermont, after reviewing their origin and history up to the present time, said that of all the countries in Europe Holland is the one in which the greatest impetus has been given to tramway enterprise. This has been in a great measure due to the action of the Netherlands Government, in granting concessions to tramway companies on the most favourable terms. On the 31st December, 1884, the total length of the Dutch lines amounted to 388 miles, and the number of tramway locomotives to 166. The rolling stock consisted of 712 passenger carriages and 305 goods waggons. The number of passengers carried during the year 1883 was 24,269,000, and the receipts from them amounted to £250,540, and from goods to £11,912. In the course of last year several new lines were opened. In England, where in the year 1876 there were only 158 miles of tramway lines, there existed on the 30th June, 1884, 751 miles; and over these lines nearly 331,000,000 passengers were carried in 1884. As regards Germany, the development is equally remarkable. The first urban tramway line laid down in that country, that of Berlin-Charlottenburg, was opened in 1865; the pecuniary results were at first far from satisfactory, and it was only after considerable time that the public became reconciled to the new system of conveyance. At first the German Government hesitated to allow tramway lines to be laid down in the more frequented thoroughfares, and it has only been during the last ten years that any marked development has taken place in the system in Germany, and at the present time it is the exception for a town of any importance to be without tramways, as they are now considered to be indispensable. In Berlin alone 76,000,000 persons used the tramways in 1884. In the 1879, there were only 24 towns in Germany provided with tramways, with a total length of line amounting to 300 miles; in 1883 this extent had increased to 561 miles, distributed among 48 towns and 43 companies, with 8,100 horses and 69 locomotives, while the total capital amounted to £5,000,000 sterling. The foregoing only relates to these tramways in the interior of German towns. The number of passengers carried over the whole of the German lines amounted to 164,000,000 in 1883, and 190,000,000 in 1884. In the Austrian capital tramways conveyed 36,000,000 of passengers in 1884, as compared with 30,000,000 in 1881. America may be termed the cradle of tramways; nowhere in the world are so many to be met with as in that country. In North America there are 3,000 miles of urban tramway lines. In the State of New York alone, at the end of 1884, there were 490 miles of tramway lines, in Massachusetts 310 miles, and in Pennsylvania 533 miles. As regards South America, it is stated that there are more than 900 miles of line, chiefly in Buenos Ayres. In American towns in 1882, 1,212,000,000 of passengers were carried over the various tramway lines, and the number of horses and carriages amounted to 100,000 and 18,000 respectively. In France, out of a total concession of 440 miles, 397 are actually in working order in the various towns, of which 155 miles, worked by 5,000 horses, are in Paris. In Italy there has been a great impetus given to steam tramway enterprise in the rural districts, and at the present day the extent of lines is about 621 miles, but in the towns the system, since 1879, has not been largely extended. It is stated that there are only 124 miles of lines, distributed principally between the cities of Turin, Milan, and Naples, and the traction in these cities is done by horses and mules, and very rarely by locomotives. In Greece, a tramway line is being constructed between Athens and the Piræus. Turkey is represented by the Constantinople tramway. Russia owns 373 miles of tramway lines. In Spain there is an extent of 62 miles of lines in the towns; while in Portugal there is only one city supplied with tramways, that is Lisbon. The extent of Belgian urban lines, which amounted in 1874, to 38 miles had increased in 1882 to about 93 miles of single line. Brussels alone, in 1882, had an extent of 44 miles, and Liège had 10 miles, exclusive of the Liège-Jemmapes tramway, which had a total length of 4 miles. There are also tramways at Gand, Antwerp, and Louvain, and trains called tramway trains on the lines from Liège to Visé. In Australia, in 1884, the colony of New South Wales was represented by a total length of 22 miles of tramway lines.

INDUSTRY AND COMMERCE OF SERVIA.

The production of wool in Servia is one of the most important sources of wealth, and especially in the mountainous districts, the annual production being estimated at about 1,500,000 kilogrammes. Rugs, gold embroidery and linen, also form an important branch of manufacture. In some cases machinery is used for the production of these articles, and every encouragement has been given by the Servian Government to foreign workmen being employed in order to instruct those of that country in all manufacturing processes. Goods are shipped to France by the Danube steamers to Galatz, and from thence are carried to Marseilles by those of the Messageries Maritimes. The exports to Germany and Switzerland go up the Danube by steamer as far as Passau, and from thence are forwarded to their destination by rail.

In 1881, between 60,000 and 80,000 hectolitres of wine were exported from Servia. The wine producers of that country are looking forward to the completion of the railway from Belgrade to Risch Pirot and to Nisch Vranga. A bottle of good Negotine wine costs at Belgrade from 1·87 to 2·50 francs. Servia is without any regular port, but has numerous stopping places on its rivers, the principal being Belgrade, Labrech, Obrenovatz, and Chabatz on the Sava; Semendria, Kladovo, Dobrovitza, Polaravaz, and Radnievaz on the Danube, at which towns annual fairs or periodical markets are held, which form an important means of exchange of merchandise of every description, and for providing the small traders in the interior with goods.

The towns of Semendria, Nisch, Vranja, are the principal marts for the products of the valley of the Morava, whilst the agricultural products of the departments of Nigotine, Ovijtz, and Tohatchats, are sent to Labrech and Chabatz, which is at the same time an outlet for those of Drine and Eastern Bosnia.

Amongst the products which rank next in importance to wool may be mentioned leather, and staves for casks and barrels; those for the wine barrels used at Bordeaux are always in great demand, and for the small casks used in Servia, Hungary, and neighbouring wine districts. The price, however, is subject to great oscillation.

The principal towns in the interior no longer depend upon Belgrade for communication with other countries, but have direct intercourse with the bordering states. With regard to the import trade, Vienna supplies principally manufactured goods, Pest the iron and window glass, Shesia linen and spun goods; cloth and woollen goods are supplied from Bohemia, whilst Trieste furnishes groceries, and Germany hardware of every description.

Correspondence.

COMMERCIAL MUSEUMS OF INDUSTRIAL EXAMPLES.

My attention has been directed to a letter which appeared in the *Journal* of January 22nd, relative to "Museums of Trade Patterns," from Mr. Lewis F. Day, who states that such a museum would obviously be of great advantage to manufacturers, whose proper business it would be to provide it, and no one else's, and this they are unwilling to do. But that such a collection could be formed by manufacturers in a casual way (and unless a collection were perfect it would be of little use), a very brief examination will show to be next to impossible.

Producers might, or might not, as they felt inclined, send their own productions to a museum, as is the case at the one established at Mulhouse, where greater liberality of feeling for the common good exists, and less trade jealousy is felt than unfortunately obtains in most manufacturing towns in England; but it would certainly not belong to the province of any one, or several manufacturers, to busy himself or themselves *con amore* in procuring all the patterns that are necessary to be obtained to form such a collection from abroad or elsewhere, and holding themselves responsible for its proper management; but it must become the business of a person who has his heart—so to speak—in the work of making an effective collection, for if left to chance efforts or spontaneous good will, it would be easy enough to foretell the ultimate inefficiency of any museum formed under such auspices.

Nor do I consider the whole subject was properly grasped upon the occasion when I had the honour of reading my paper to the meeting, the main idea that was uppermost in the minds of the speakers being that it was a collection of designs or patterns that was chiefly suggested to be made.

So far as mere designs are concerned, I think we are well abreast with the times, and have no deficiency here to complain of; the South Kensington Museum, with its drawing classes and other arrangements, having successfully stimulated this department to a greater extent than credit is commonly given to it, in which I heartily concur with my old friend Mr. Wallis; but the main usefulness of such museums, from a commercial point of view, would be found in the collection of industrial examples, fabrics, or trade specimens themselves, which would often be valuable irrespective of design—in short, that commercial or trade museums should be erected which would afford business information quite distinct from art, though of course the latter is to be by no means overlooked.

To give an instance of my meaning, I may point out that recently, at a special meeting of the Wolverhampton Chamber of Commerce, an address on the effects of continental competition upon the English hardware trades in the colonies, was delivered by Mr. W. W. Walker, of the firm of Messrs. T. W. and T. Walker, hardware merchants, Wolverhampton; the President of the Council (Mr. T. C. Tildesley) stating that the Germans were pushing English makers very hard, not only in our own colonies, but also, he was sorry to say, in their own district.

After giving statistics proving that Germany did a greater trade with some of the continental countries than England, Mr. Walker drew attention to the formidable increase in the production of German iron and steel wire. The imports of this material from the United Kingdom had decreased from 86,653 tons in 1882 to 52,968 in 1884, whilst those of Germany increased from 32,000 in 1877 to 212,794 in 1884. In this latter year, Germany exported to England 57,314 tons of wire. After similar instances of an analogous kind, Mr. Walker remarked that there was not a man within fifty miles of Birmingham who could make a spring divider; and there were only about two men who could make wrought-iron vices. In fact, for tools which required clever handiwork, the rising generation were not filling their fathers' places. As to brass cabinet locks (Mr. Walker continued) the trade of South America, and other markets, was going into German hands. The rim and padlock trade, he was pleased to say, was still maintained by English firms. As to the quality of the German goods there could be no doubt. They had introduced the best machinery, and their workmen had received good technical instruction.

Mr. Walker added that, when in Australia, he had seen German fencing-wire, which was coated with a transparent varnish and neatly packed in kegs, sold as much as 2s. 6d. per ton below English quotations. The wire was mech preferred by the colonists. Sofa springs were much below English prices, and German brass locks, splendidly finished, were sold for 7s. 9d.

I am quite ignorant of the details of the hardware business, my knowledge being confined mainly to the textile branches, which are subjected to the most severe competition of any; but it will be very clear to anyone that, if a collection of patterns—a museum of trade examples—were founded at Wolverhampton, so that those interested might obtain information, and see for themselves what was brought against their own production from other markets, it would be the means of rendering the district a very valuable assistance, and set ingenuity and contrivance at work that now needs to be stimulated.

That others are of my way of thinking may also be gathered upon the occasion referred to, for at the suggestion of Mr. S. Theo. Mander, the Chairman promised that the consideration of the establishment of a museum, to contain specimens of foreign workmanship, should be brought before the Council.

It has been brought forward as an argument that manufacturers would naturally be unwilling to assist in bringing about a competition in what they were doing themselves by officiously exhibiting their own productions, or samples of them. This of course may be assumed; but, on the other hand, it appears to me that it would be much more undesirable—nay, even unfair—to make colourable imitations of objects registered in the office of the Registrar of Designs in Chancery-lane, which it has been suggested would answer the same purpose as a museum of patterns—limited in scope and intent as it is—for this would be an unjustifiable interference with the special rights of individuals protected by fees paid for such protection, and which it would be neither fair nor right to infringe.

William H. Ablett.

COLONEL BEAUMONT'S COMPRESSED-AIR ENGINE.

My attention has been called to an error in the figures which I had obtained from the Report of the Jury, and which I gave in my paper upon the results of the competition between tramway motors at the Antwerp Exhibition. I should feel obliged by your allowing me to correct the error from revised figures which I have to-day received from Brussels.

The quantity of coke consumed to warm the compressed-air as it escaped from the cylinders on the motor is stated to have been 0·49 kilogrammes per kilometre run, and the coke employed was a very cheap gas coke.

Douglas Galton.

12, Chester-street, Grosvenor-place, S.W.,
9th February, 1886.

My attention has been drawn to Captain Douglas Galton's paper on the recent tramway trials at Antwerp, and especially to the consumption of fuel by the compressed-air and electric engines, respectively; the figures given appeared to me to be so contrary to facts, that I wrote to Captain Galton, who at once said that, as regards electricity, they were only estimates; after which I have, of course, nothing to say, except to regret that this was not made clear in the paper.

I have had no official copy of the Jury's report, but I am sure I am right in saying that the amount of fuel supplied to the electric car, adjoining the compressed-air shed, was about the same, and as the air-engine was taking nearly twice as much weight as the electric car, the fuel consumed in proportion to work done should certainly have been less for air than electricity. The coke stated to have been consumed in heating the air is simply unintelligible to me, as the small boiler I had could not have burnt the quantity, viz., 3 lbs. per mile, and, as regards the water, it runs back into the boiler, after it has been used in warming the cylinders. Respecting the total coal consumption, the compressors were too large for one car, and were of a temporary character. The air-engines were sent to Antwerp to demonstrate one fact only, viz., the quantity of air required to do a given amount of work on a tramway, and on this point the report is entirely satisfactory, viz., 34 lbs. of air moved a gross load of 13 tons one mile, including many stoppages.

It is a matter of ordinary calculation what fuel is necessary to raise 34 lbs. weight of air from the pressure of 1 atmosphere to 68, and this with properly constructed engines, will be found to be about 8 lbs. This estimate is borne out by returns of running on an extended scale on the Liverpool tramways.

The trials at Antwerp were made under conditions which are not obtained in England, and the absence of inclines made any results utterly useless as proving that the engines could work ordinary English traffic, under our Board of Trade regulations, and without showing steam.

I think it likely that further trials will be made, perhaps in Liverpool; it is most desirable that they should be, and when they they are concluded I feel quite certain a totally different complexion will be put on the merits of the different systems tried at Antwerp.

FRED. BEAUMONT, Col. R.E.

Suffolk-house, 5, Laurence Pountney-hill,
Cannon-street, E.C.,
Feb. 15, 1886.

MACHINERY IN MINES.

Mr. Shone has expressed doubt as to the value of some facts I gave in my paper, and assumes that the low efficiency of the air experiments was due to defective mechanism. I must say that Mr. Shone is absolutely and totally wrong in his assumption. I attempted in my paper to give the general results of collective experience, and not the result of any experiment got up to support any "fad" of my own, and I challenge Mr. Shone to prove that I am wrong. My paper was intended to be a brief record of ascertained facts, and it would be more to the purpose if Mr. Shone would meet my arguments by facts instead of by vague generalisations expressed in involved arithmetic. I shall not uselessly occupy your space by giving cuttings from text-books, but I would commend to Mr. Shone the following consideration. The heat of compression in air expresses, in Joule's equivalent (772), the work done in compressing the air, and that work is totally lost if the air is used without expansion after it has been cooled down to the normal temperature. To take an example approximately. One pound (13 cubic feet) of air heated by compression 980° Fahr. absorbs 232 units of heat, $232 \times 772 = 179{,}104$ foot-pounds. Thirteen cubic feet of air at 60 lbs. absolute pressure without expansion, would perform in foot-pounds, $144 \times 13 \times (60 - 15) = 84{,}240$ foot-pounds only; there is, therefore, about 50 per cent. less of efficiency, due to compression alone, in that particular case. With water pressure that loss would not occur, because neither the temperature nor the volume of water are sensibly altered by compression.

It is not for me to say what the efficiency of Mr. Shone's system is. He speaks of what *it might be*, but it would be more interesting, and much more to the purpose, if he would tell us what it is from practical trials.

HENRY DAVEY.

I am not answerable for the correctness of the report of what was said in the discussion on Mr. Davey's paper. If, however, Mr. Shone had been desirous of asserting the truth, he could not have overlooked the fact, which appears in the report, that the loss by compression of air heated 260° was stated by me to be 33 per cent., which of course implies that the heat developed increased the air by one-third, and not three times as reported. Again, when I compared water at 400 lbs. with air at 40 lbs. pressure, it was simply to show that 4½ times as much power was required to transmit power by air through a pipe of the same size as by water of the stated pressure. What, therefore, becomes of the pretty little calculation intended to show that the useful effect was 110 per cent., a proposition that nobody but a lunatic would propound?

With reference to the figures Mr. Shone quotes referring to Warrington, in that case air of 27 lbs. pressure was used to lift the sewage 10 feet, and the result of this experiment was reported to a public Board, not by me, but by a member of the Institution of Civil Engineers who witnessed it. Now, as the Shone ejector does not work expansively, the enormous loss was at once apparent in this case.

Up to the present time no reliable results of the cost of the Shone system have been made public, and being very desirous that authentic information should be forthcoming, I may say that I communicated with Mr. Shone, who subsequently wrote to me on the 20th November, 1883, as follows:—"To set at rest the question as to the loss of power involved in the application of my system, I hereby offer, on behalf of the sole licensees of the system, to demonstrate to you, and anybody else of your mind, in the presence of Mr. Hawkesley, C.E., and in the presence of Messrs. Simpson and Co., of Grosvenor-road, Pimlico, S.W. (the eminent manufacturers of pumping machinery), the fact that I can get 66 per cent., and not 20 per cent. as you state, of the engine-power employed to compress air, for utilising upon my system . . . . provided you will undertake to subscribe towards the cost such a sum as will be sufficient or reasonable under the circumstances to enable the licencees to undertake the expenditure without serious loss, in the event of my demonstration proving a success, and not a failure. Otherwise the whole cost will be borne by the licencees."

To this offer I replied on the 27th November, 1883:—"I am quite willing for you to make your own experiments if you will give me an opportunity of testing the results. Now as such experiment need not be an expensive affair—for I presume you still have the experimental apparatus fixed at Wrexham, which I had the opportunity of seeing at work—and as such authoritative experiment, if it corroborates your views, must naturally be an advantage to you, while it cannot be any possible advantage to me from a pecuniary point of view, I am quite willing to concur in your suggestion that Messrs. Simpson's men should take charge of the apparatus for, say, a week's experiment, and that Mr. Thos. Hawkesley, C.E., shall determine the efficiency of the apparatus, and that you and your assistants shall be present, and I and my assistants shall also be present, simply to take notes, and under these conditions I am quite willing to subscribe fifty pounds towards the cost of the experiment, provided I am supplied with the authoritative results."

I may add that, up to the present time, Mr. Shone has not had the experiment he proposed made, and until it is done I shall continue to believe that air is the most extravagant of all modes of transmitting power for raising sewage.

In conclusion, allow me to say that, in reference to the authorities Mr. Shone quotes in his communication, in the Birmingham report by Mr. Sturgeon and others, the useful effect of cold air without expansion at 40 lbs. pressure is stated to be 27·1 per cent. What, therefore, becomes of the calculation showing that air at 54 lbs. gives a useful effect of 45 per cent., for the higher the pressure the greater is the loss?

BALDWIN LATHAM.
M.Inst.C.E., F.G.S., &c.

7, Westminster-chambers, S.W.,
9th February, 1886.

ARTISTIC BRONZE CASTING.

The method of making moulds for the *Cera perduta* process appears to me to be antiquated and by no means simple, or likely to give certain results. The material used for the cores, *i.e.*, plaster of Paris and brickdust or loam, although firm when set, becomes friable and weak after firing, causing great liability to waste and risk of sandy dirty castings. A certain amount of plaster is necessary for constructive purposes, but some binding material, such as soda or other flux, should be mixed with the core to bind it together, when burnt; the venting of the cores may be greatly assisted by adding sawdust to the mixture, which burns out, leaving the core porous, and assisting its strength by the fusible salts contained in the wood.

For the outer mould a first layer of very fine loam, ground in petroleum oil, should be applied with a brush, and over this a few coats of a mixture of fine sawdust and loam, to which has been added a proportion of short fibrous asbestos, the outer casing being made of the same mixture but coarser. Each coating must be put on in such a manner by the point of the brush as to leave a rough surface, which readily binds and adheres to the next coating, and it will, of course, be understood that the asbestos fibre must be mixed by hand; if ground in a mill the fibre is destroyed, and the asbestos becomes useless. A mould made in this manner can be done rapidly, dries in a short time, and will never crack; in fact, it is strong enough to stand the pressure of the fused metal in small work without binding or any external assistance, and there is no risk in handling the moulds without any special care. I have lifted a block of this material between 30 and 40 lbs. weight when half dried, by one corner, and dropped it a distance of 3 ft. without a crack appearing. The system of pouring the metal from underneath is not so important with these moulds, they are as firm as an ordinary Bath-brick, at the same time it is always advisable for artistic work where fine surfaces are necessary; the air outlets may be formed by thin sticks of wax as they can be numerous and very small, but the "gate" or inlet for the metal is usually much better for large surface work if made wide and very narrow, and if of this shape it can usually be placed where it can be cut off and no finishing is necessary.

There is one method of pouring which is only practised for some special purposes, but which would give perfect results in figure casting, as the metal flows calmly in without any rush or disturbance. In this method the gate or inlet is at one side near the bottom, the basin or "sow" is immediately below it, and the basin and mould are fastened together and mounted on a swivel. As soon as the melted metal is placed in the basin the whole is gradually tilted over, the metal flowing quietly from the basin into the mould, the vents and riser being of course on the same side as the gate or inlet, so that when the mould is turned completely over all the openings are on the upper side.

Many castings are liable to be spoilt through deficiency of metal; this can always be obviated by taking a known bulk or weight of modelling wax for the work, and weighing the remainder after the work is done. A little simple calculation will enable the correct quantity of metal to be ascertained, and an allowance of about 25 per cent. additional will cover all necessary for gate, riser, and vents.

THOS. FLETCHER.

Thynne-street, Warrington.

Notes on Books.

REPORT ON THE EXHIBITS RELATING TO THE CHEMICAL INDUSTRIES IN THE INTERNATIONAL INVENTIONS EXHIBITION, 1885. By Watson Smith. Manchester. 1885.

This pamphlet is a reprint, with additions, from the *Journal of the Society of Chemical Industry.* It contains an account of the various chemical processes, and the machinery used for those which were shown at the Exhibition, also a description of the materials exhibited. A tabulated list of dyes, &c., discovered and manufactured by the Badische-Anilin-und-Soda-Fabrik, is added.

GOD AND MAMMON. By James Platt. London: Simpkin, Marshall, & Co.

This work, by the author of Essays on Business, Morality, Money, and Economy, is intended to exhibit a theory of life by which it is possible to serve both God and Mammon.

A GENERAL HISTORY OF MUSIC FROM THE INFANCY OF THE GREEK DRAMA TO THE PRESENT PERIOD. By W. S. Rockstro. London. Sampson Low, Marston, Searle, and Rivington. 1886. 8vo.

The object which the author set before him in the production of this book was to provide in a single volume of moderate size an account of the entire history of music. The works of Burney and Hawkins, although full of valuable information, are both cumbrous and expensive, and several of the modern works on the subject are written in French and German, and are not to be obtained in English translations. This work is divided into six books. The first treats of the music of the Greeks and of the Early Christians; the second of music in the Middle Ages. Music in the seventeenth century is the subject of the third book, and chapters are devoted to the invention and early history of the opera and oratorio. In the chapter devoted to the English school of the Restoration there are illustrative extracts from the Diaries of Pepys and Evelyn, and an account of the re-organisation of the choir of the Chapel Royal, under the famous Captain Henry Cooke. Dr. William Child, Dr. Christopher Gibbons, and Edmund Low, were among his colleagues, and three of his first set of choristers, Pelham Humphrey, John Blow, and Michael Wise, became leaders of the new English school. Henry Lawes, whose association with Milton has made his an undying name, was appointed "Clerke of the Checke," and Henry and Thomas Purcell, father and uncle respectively of the great Purcell, were among the gentlemen of the Chapel Royal. Of these men, and of Purcell and his successors, the author writes:—"The names of these worthies are still venerated in every cathedral choir in England, and by their earnest efforts and sincere love for art, the traditions of the school of the Restoration were kept alive in England, until the arrival of Handel in the year 1710." In the fourth book is an account of music in the eighteenth century, and notices of the Seven Lamps or bright luminaries whose influence upon art is ineffaceable. These are Palestrina, Handel, Bach, Gluck, Haydn, Mozart, and Beethoven. In the fifth book the reader is introduced to the seven lesser lights, Schubert, Weber, Spohr, Mendelssohn, Schumann, Cimarosa, and Cherubini. Chapters are devoted to the condition of dramatic music in Italy and France during the closing years of the eighteenth century, and in the fifth book to the German, the French, and the English schools of the nineteenth century. The consideration of the present condition of music, and its probable influence upon the future, occupies the sixth book, a chapter of which is specially devoted to Wagner. In an appendix there is an Epitome of the Technical History of Music from the earliest ages to the present, and united with the index is a chronological table of the chief matters treated of in the book; thus the births and deaths of the composers, the musicians, and singers are given, and the dates of the chief compositions. There are illustrations of a Stradivari violin, Handel's harpsichord, spinets, a clavichord, and the Haarlem organ, and small portraits of the great composers.

LE CLERGÉ FRANCAIS RÉFUGIÉ EN ANGLETERRE. Par. F. X. Plasse. Paris. 1886. 2 vols., 8vo.

This is a history of the exile in England of the large number of French ecclesiastics who came to this country during the troubles of the great French Revolution. There were three great currents of emigration, the first in 1792-93, the second in 1794-95, and the third in 1797-99. Canon Plasse has drawn from a large mass of authentic documents a full account of these currents of emigration. He then traces the movements of the various individuals in London, Jersey, Winchester, Reading, Ipswich, and many other places. At the end of the second volume is a table of the emigrant clergy, giving their names, titles, and residences in England. There is also an account of the chapels built in various parts of the country for these priests and through their influence. The book is fully illustrated with views of the places of most note where the emigrants were settled.

General Notes.

EXPORTS OF STAVES FOR BARRELS FROM ITALY.—A considerable quantity of staves and hoops for barrels are exported annually from Italy to the French ports in the Department of the Alpes Maritimes. In 1884, 1,780 tons of staves and 288¾ tons of hoops were shipped to the four ports, viz., Nice, Cannes, Antibes, and Mentone, against 1,263½ tons of staves and 244 tons of hoops in the previous year. The principal Italian ports which carry on this trade are Castellamare di Stabia, Granatello, Tetri, Leghorn, Civitavecchia, Savona, and Finale Marina.

CORINTH CANAL.—During the past autumn the works of the canal through the isthmus of Corinth have been pushed forward vigorously. In August, 150,690 cubic metres of earth were excavated, and in September, 143,309 cubic metres, or 302,999 cubic metres for the two months, being 20,000 in excess of that excavated during the preceding two months. It is anticipated shortly that the contractors will be in a position to excavate not less than 200,000 cubic metres per month. The foundations for the railway bridge, which will cross the canal, are now completed. This bridge will be of iron, with stone piers and abutments.

THE MERCHANT NAVY OF THE WORLD.—The *Bureau Veritas* publishes the following statistics respecting the merchant navy of the world in 1885. The total number of sailing vessels in existence that year was 43,692, with an aggregate tonnage of 12,867,375; that of steamers was 8,394, with a tonnage of 6,719,101, making a total of 52,086 vessels, and 19,586,476 tons. The largest fleet, naturally, is that of England, with 4,852 steamers, with a tonnage of 4,159,003, and 14,939 sailing vessels, of 4,714,746 tons. Next follows France, with 505 steamers, of 498,646 tons, and 2,173 sailing vessels, of 398,561 tons. Germany possesses 509 steamers, with a tonnage of 110,064, and 2,424 sailing vessels, with 863,611 tons. With regard to the importance of their steam navy, the maritime countries are classified as follows:—England, France, Germany, United States, Spain, Holland, Italy, Russia, and Norway, which last country owns 103,792 tons of steam shipping. With regard to sailing vessels, the classification as regards importance is as follows:—England, United States, Norway, Germany, Italy, France, Russia, Spain, Sweden, and Holland.

FORESTS IN FRANCE.—From a recently published report of the Administration of Forests, it appears that the area covered by woods and forests in France is 8,396,131 hectares; of which 1,012,688 hectares belong to the Government; 1,967,846 hectares are communal; and the remaining 5,415,567 hectares are private property; an hectare being equal to 2 acres, 1 rood, 35 poles. Between the years 1826 and 1884, 465,038 hectares were cut down, and 37,267 hectares replanted with trees. The value of the Government forests is estimated at 1,300,000,000 francs, and the annual revenue derived from hem between 30,000,000 francs and 35,000,000 francs. For the present year the sum of 35,582,600 francs figures in the budget as the revenue from this source. The cost of administration and maintenance, however, is very great, and for the present year will be 17,772,000 francs, or nearly half the gross revenue, and leaves barely 19,000,000 francs of net revenue, which only represents about 1½ per cent. on the capital, or 19 francs per hectare, whilst woods and forests belonging to private persons yield from 28 francs to 30 francs. It must be mentioned that these figures include the amounts paid for right of shooting, which in many cases is leased at high prices.

MEETINGS OF THE SOCIETY.

ORDINARY MEETINGS.

Wednesday evenings, at Eight o'clock:—

FEBRUARY 24.—"The employment of Autographic Records in Testing Materials." By Prof. W. C. UNWIN.

MARCH 3.—"Calculating Machines." By C. V. BOYS.

MARCH 10.—"The Experiments with Lighthouse Illuminants at the South Foreland." By PRICE EDWARDS. Lord RAYLEIGH, Secretary of the Royal Society, will preside.

MARCH 17.—"Domestic Electric Lighting." By W. H. PREECE, F.R.S.

APRIL 14.—"The Treatment of Sewage." By Dr. C. MEYMOTT TIDY.

FOREIGN AND COLONIAL SECTION.

Tuesday evenings, at Eight o'clock:—

MARCH 2.—"Bechuanaland and Austral Africa." By JOHN MACKENZIE, late Deputy Commissioner of Bechuanaland.

MARCH 23.—"The Commercial Progress of New South Wales." By EDWARD COMBES, C.M.G.

April 13; May 18.

APPLIED CHEMISTRY AND PHYSICS SECTION.

Thursday evenings, at Eight o'clock:—

FEBRUARY 25.—"Photography and the Spectroscope in their Application to Chemical Analysis." By Professor W. N. HARTLEY, F.R.S. Professor Sir HENRY E. ROSCOE, F.R.S., M.P., will preside.

MARCH 11.—"Film Photography." By L. WARNERKE. Captain ABNEY, F.R.S., will preside.

MARCH 25.—"Certain Methods for the Utilisation of Refuse and Dust Fuels." By WALTER G. MCMILLAN, F.C.S., Demonstrator of Metallurgy, King's College, London.

APRIL 8.—

MAY 13.—"The Scientific Development of the Coal Tar Colour Industry." By Professor R. MELDOLA, F.C.S.

INDIAN SECTION.

Friday evenings, at Eight o'clock :—

FEBRUARY 19.—"Historical and Recent Indian Famines." By F. C. DANVERS, F.S.S., Registrar and Superintendent of Records, India-office. J. M. MACLEAN, M.P., will preside.

MARCH 19.—"Experiences on the Afghan Frontier." By WILLIAM SIMPSON. Col. HENRY YULE, C.B., will preside.

APRIL 2.—"Archæology in India." By JAMES GIBBS, C.S.I., C.I.E., late Member of the Viceroy's Council.

May 7, 21.

The above dates are liable to alteration.

CANTOR LECTURES.

The Third Course will be on "Science Teaching." By PROF. F. GUTHRIE, F.R.S.

Lecture II.—February 22.—Knowledge about Common Stuffs and Things.

Lecture III.—March 1.—Teaching Physics.

MEETINGS FOR THE ENSUING WEEK.

MONDAY, FEB. 22...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. (Cantor Lectures.) Prof. F. Guthrie, F.R.S., "Science Teaching." (Lecture II.)

Surveyors, 12, Great George-street, S.W., 8 p.m. Mr. Wm. Woodward, "London Remodelled."

Geographical, University of London, Burlington-gardens, W., 8½ p.m. Mr. Alex. Hosie, "A Journey in South-Western China, from Ssuchûan to Western Yunnan."

Actuaries, The Quadrangle, King's College, W.C., 7 p.m.

Medical, 11, Chandos-street, W., 8½ p.m.

London Institution, Finsbury-circus, E.C., 5 p.m. Mr. J. C. Morison, "English Life in the XV. Century, as depicted in the Paston Letters."

TUESDAY, FEB. 23...Royal Institution, Albemarle-street, W., 3 p.m. Mr. C. T. Newton, "The Unexhibited Portion of the Greek and Roman Sculptures in the British Museum." (Lecture II.)

Medical and Chirurgical, 53, Berners-street, Oxford-street, W., 8½ p.m.

Civil Engineers, 25, Great George-street, S.W., 8 p.m. Discussion on Mr. L. F. Vernon-Harcourt's paper, "The River Seine."

Anthropological, 3, Hanover-square, W., 8½ p.m. 1. Mr. A. W. Howitt, "Australian Medicine Men." 2. Mr. Adolphus Mann, "The Numerals of the Yoruba Nation."

WEDNESDAY, FEB. 24...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. Professor W. C. Unwin, "The Employment of Autographic Records in Testing Materials."

Geological, Burlington-house, W., 8 p.m. 1. Rev. P. B. Brodie, "Two Rhætic Sections in Warwickshire." 2. Mr. E. Witchell, "The Basement-beds of the Inferior Oolite of Gloucestershire." 3. Mr. Percy F. Kendall and Mr. Robert G. Bell, "The Pliocene Beds of St. Erth"

Patent Agents, 55, Chancery-lane, W.C., 7½ p.m. 1. Mr. G. G. M. Hardingham, "Patent Applications with Provisional Specifications." 2. Mr. Ernest de Pass, "Is it Expedient to Continue the Practice of lodging Provisional Specifications?"

Royal Society of Literature, 4, St. Martin's-place, W.C., 8 p.m.

Civil and Mechanical Engineers, 7, Westminster-chambers, S.W., 7 p.m. Mr. B. Haughton, "Wave Motion."

THURSDAY, FEB. 25...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m (Chemical and Physical Section.) Prof. W. N. Hartley, "Photography and the Spectroscope in their Applications to Chemical Analysis."

Royal, Burlington-house, W., 4½ p.m.

Antiquaries, Burlington-house, W., 8½ p.m.

London Institution, Finsbury-circus, E.C., 5 p.m. Mr. R. A. Proctor, "Volcanoes."

Royal Institution, Albemarle-street, W., 8 p.m. Prof. W. Boyd Dawkins, "The Ancient Geography of Britain." (Lecture I.)

Telegraphic Engineers and Electricians, 25, Great George-street, S.W., 8 p.m. Resumed Discussion on Professor D. E. Hughes's paper, "The Self-Induction of an Electric Current in Relation to the Nature and Form of its Conductor."

Social Science, Prince's-hall, Piccadilly 11 a.m. Conference on Temperance Legislation.

FRIDAY, FEB. 26...United Service Institute, Whitehall-yard, 3 p.m. Lieutenant-General Sir Gerald Graham, "Fire Discipline, Fire Tactics, and the use of Square Formation."

Social Science, Prince's-hall, Piccadilly, 10½ a.m. Conference on Temperance Legislation continued.

Royal Institution, Albemarle-street, W., 3 p.m. Weekly Meeting, 9 p.m. Mr. A. A. Common, "Photography as an Aid to Astronomy."

Civil Engineers, 25, Great George-street, S.W., 7½ p.m. (Students' Meeting.) Mr. Henry A. Cutler, "Stability of Voussoir Arches."

Quekett Microscopical Club, University College, W.C., 8 p.m.

Clinical, 53, Berners-street, W., 8½ p.m.

Browning, University College, W.C., 8 p.m. Mr. Albert Fleming, "A Broken Life—Andrea del Sarto."

SATURDAY, FEB. 27...Physical Science Schools, South Kensington, S.W., 3 p.m. 1. Professor W. C. Unwin, "Notes on the Thermodynamic Relations in the paper of Messrs. Ramsay and Young." 2. Mr. Walter Baily, "A Map of the World in which the Proportion of Areas is Preserved."

Botanic, Inner Circle, Regent's-park, N.W., 3¾ p.m.

Royal Institution, Albemarle-street, W., 3 p.m. Rev. C. Taylor, "The History of Geometry. The Greek and the Modern." (Lecture I.)

ROYAL COMMISSION FOR THE
COLONIAL AND INDIAN EXHIBITION, LONDON, 1886.

Executive President—HIS ROYAL HIGHNESS THE PRINCE OF WALES, K.G.
Secretary—SIR PHILIP CUNLIFFE-OWEN, K.C.M.G., C.B., C.I.E.
Assistant Secretaries—EDWARD CUNLIFFE-OWEN, ESQ., B.A.; J. R. ROYLE, ESQ. (for India).

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A	DOMINION OF CANADA.	The Hon. Sir C. Tupper, G.C.M.G., C.B.
B	NEW SOUTH WALES	Sir Alexander Stuart, K.C.M.G.
C	VICTORIA	R. M. Smith, Esq., C.M.G.
D	SOUTH AUSTRALIA	Sir A. Blyth, K.C.M.G.
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F	WESTERN AUSTRALIA	The Hon. Malcolm Fraser, C.M.G., J.P.
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L	ST. HELENA	Lieut.-Col. Edmund Palmer.
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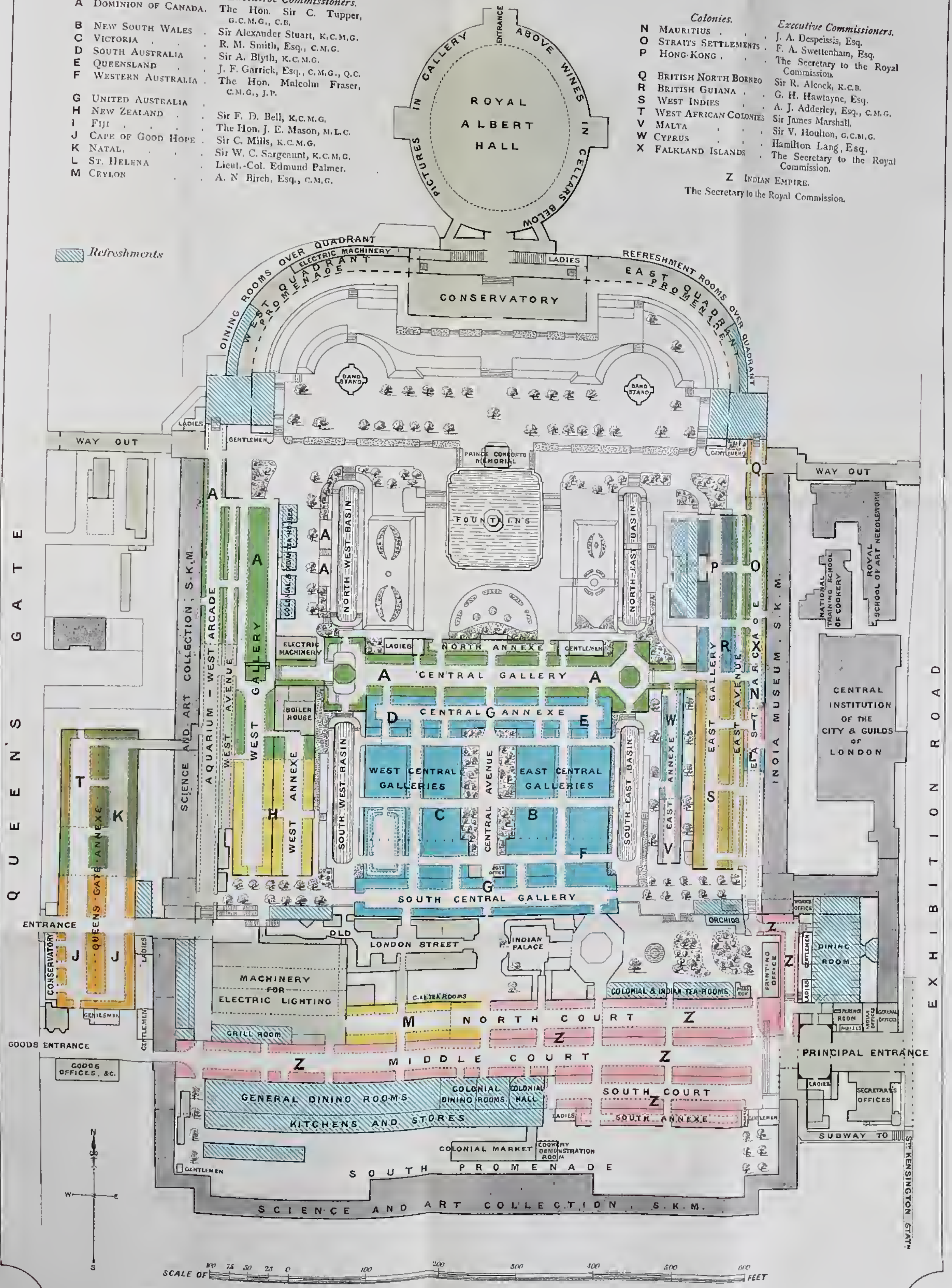
O	STRAITS SETTLEMENTS	F. A. Swettenham, Esq.
P	HONG-KONG	The Secretary to the Royal Commission.
Q	BRITISH NORTH BORNEO	Sir R. Alcock, K.C.B.
R	BRITISH GUIANA	G. H. Hawtayne, Esq.
S	WEST INDIES	A. J. Adderley, Esq., C.M.G.
T	WEST AFRICAN COLONIES	Sir James Marshall.
V	MALTA	Sir V. Houlton, G.C.M.G.
W	CYPRUS	Hamilton Lang, Esq.
X	FALKLAND ISLANDS	The Secretary to the Royal Commission.

Z INDIAN EMPIRE.
The Secretary to the Royal Commission.

▨ *Refreshments*



February, 1886.

Wilson Bennison, Surveyor to the Royal Commission.

Wm Clowes & Sons Limited Duke St Stamford St S.E.

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Journal of the Society of Arts.

No. 1,736. Vol. XXXVI.

FRIDAY, FEBRUARY 26, 1886.

All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

NOTICES.

CANTOR LECTURES.

Professor Guthrie, F.R.S., delivered the second lecture of his course on "Science Teaching," on Monday evening, 22nd inst.

The lectures will be printed in the *Journal* during the Easter recess.

Proceedings of the Society.

INDIAN SECTION.

Friday, February 19th, 1886; J. M. Maclean, M.P., Member of Council, in the chair.

The paper read was—

HISTORICAL AND RECENT FAMINES IN INDIA.

By F. C. Danvers.

In recent times the famines that have, at somewhat irregular intervals, visited different parts of India, may be said to have been due to failure of the periodical rains upon which the cultivation of the soil is, in most parts, entirely dependent. In historic times, however, local famines have sometimes been caused, and at others greatly aggravated, by the devastation arising from hostile incursions. The latter cause has now, happily, ceased as an element to be taken into consideration in connection with the subject before us. With regard to the former, some few preliminary observations may be of interest.

The map on the wall shows, by density of colour, the average annual rainfall in four different degrees. The dark blue represents the moist zone, where there is a rainfall of seventy inches and upwards in the year; light blue, the intermediate zone, a rainfall of from thirty to seventy inches; purple, the dry zone, of from fifteen to thirty inches; and light brown, the arid zone, having a rainfall of less than fifteen inches. Of the area in which the rainfall is below fifteen inches, it may be said that it is either actually desert, or that agriculture is impossible without artificial irrigation; and hence it follows that where the rain is least copious the population has made itself in a great degree independent of the local rainfall. In the opposite direction it is also generally true that, where the rain is most abundant, exceeding forty or fifty inches, the occurrence of such droughts as will cause serious scarcity is rare. The region in which the average rainfall is between twenty and thirty-five inches is that which suffers most from droughts, and this includes the western and southern parts of the North-Western Provinces, and that portion of the Punjab territory which lies east of the Sutlej; the western and northern states of Rajputana, and of the central plateaux which border on the North-Western Provinces; the districts of Bombay above the Western Ghauts, and the districts of Madras above the Eastern Ghauts, together with the southern and western region of Hyderabad, and all Mysore except the strip lying close to the Western Ghauts; and the districts of Madras along the east coast, and at the extremity of the peninsula.

A strongly marked yearly periodicity is everywhere observed with regard to the distribution of rain over the year. The chief fall occurs, with few exceptions, in the summer months, between May and October, in the season commonly known as the south-west monsoon. On a part of the Madras coast, on the east of the peninsula, heavy rain falls after the cessation of these summer rains, in the months of November and December, at the beginning of what is termed the season of the north-east monsoon. In the more northern provinces, again, a well-marked season of winter rain occurs, commencing about Christmas, and extending to February, but its effects hardly reach south of the tropics, and it has no sensible influence on the agriculture of Southern India. The droughts and famines during the past hundred years have been mainly due to the failure of the south-west monsoon. The drought of 1865-6 in Orissa and Behar, and some of the earlier scarcities in Madras, arose from failures of the rain of the north-east monsoon on the east coast. The famine of 1873-4 in Northern Bengal was exceptional, and is an instance of a great scarcity arising in a region of abundant average rainfall owing to a premature cessation of the rain, apparently due to an abnormal extension to the eastward of the margin of the comparatively dry area of North-Western India. The map on the wall, on which the principal droughts during the past hundred years are shown collectively, illustrates the parts of India subject to such visitations. The smaller maps show the areas of those famines separately.

With these preliminary observations, I now proceed to give a brief account of 52 famines (regarding which I have been able to trace any record), extending over a period of from 2,300 to 2,400 years, of which 30 occurred in the historic period, and 22 in recent years, that is, within the last 100 years or so.

It must not be supposed that the list of historic famines here given is a complete record of those that occurred previously to the year 1769, but it contains the dates of all regarding which I have been able to trace particulars. The absence of any reference to famines by most native historians may probably be accounted for by the fact that these confined themselves principally to a narration of the deeds of emperors, and took but little account of the economic condition of the country, except in so far as it was affected by, or had any influence upon, the actions of the ruling sovereign.

In the present paper, I have carefully avoided any questions bearing upon the policy adopted, from time to time, by the Government of the day in dealing with these national afflictions. Even had it been deemed desirable to deal with that question, the time at our disposal would have effectually prevented any satisfactory treatment of that branch of the subject, which, therefore, if thought suitable for discussion, should properly form the topic of a separate paper. I have also not thought it necessary to refer to what is known as the "sun-spot" theory in connection with famines in India, the evidence on this subject being still too incomplete for any practical deductions therefrom.

From the circumstance that accounts of famines occur in some of the earliest histories of India, by native authors, it would appear that that country has always been subjected to those visitations. The scanty particulars generally given by these writers, however, do not enable any approximate area even to be ascribed to them, and other details are, for the most part, either wholly wanting, or only very scantily supplied. Seasons of drought were evidently well known in India, as in other Eastern countries, at a very early date, and allusion is made to them in the Rámáyana, where it is stated that "in the Raj of Anga there was a great drought, because of the wickedness of Lomapáda, who was the Raja of Anga." No date can be assigned to this event, and the account may indeed be treated, at least, as apocryphal.

Ferishta states that during the reign of Jeichund, who was Emperor of India between the years 503 and 443 B.C., a famine and pestilence happened, and that the Emperor himself was addicted to indolence and pleasure. After this there is a period of about 1,500 years within which none of the early historians have recorded the occurrence of any similar calamity in India; but from the frequency of their visitations since then, it would not be reasonable to suppose that the country was altogether free from them during that time.

The year 1033 was remarkable for a great drought and famine in many parts of the world, and it was especially severe in Persia and India, in which entire provinces were depopulated. It was succeeded by a pestilence, which swept away thousands of human beings.

The earliest famine in the Deccan, of which any information has been obtained, is stated to have occurred in the year 1200, and to have lasted for twelve years, during which time a great number of people died, and measures of relief are stated to have been adopted by the Delhi Government.

The year 1291 was one of severe famine in India, in which thousands perished, and the eldest son of the Emperor (Feroze II.) fell a victim to an epidemic that followed. It is stated that no rain fell for a whole year, and the price of grain in Delhi rose to a jital per seer, or about ten times its normal price. In the Siwalik, also, the dearth was greatly felt, and the Hindús of that country flocked into Delhi with their families. The Sultan and nobles did all they could to help the poor distressed people, but thousands, it is stated, daily died in the streets and highways, and, in the extremity of hunger, whole families drowned themselves in the river Jumna.

The next famine regarding which I have

traced any record, occurred after an interval of about fifty years, in 1345, during the reign of Muhammed Tughlak. This emperor caused great distress by reason of the heavy taxation imposed upon the people to meet the expenses of his military expeditions. By reason of these the poor became beggars, the rich became rebels, and many of the farmers were forced to fly to the woods, and to maintain themselves by rapine. The lands were left uncultivated, and grain consequently became scarce, famine began to desolate whole provinces, and the sufferings of the people obliterated from their minds every idea of government and subjection to authority.

The great Doorga Deevee famine is said to have taken place in A.D. 1396, and spread over the whole of Hindustan. Particulars of this calamity are wanting beyond the circumstance that it is stated to have lasted twelve years, and to have extended over the entire peninsula of India, and depopulated whole districts. It arose from a total want of seasonable rain. It cannot be ascertained whether any measures of relief were adopted at the time. During its occurrence Delhi was again, in 1398, the centre of scarcity, owing apparently to war rather than to any abnormal condition of the seasons. Many, it is stated, died of sickness, and many perished with hunger, and for two months Delhi was desolate.

Fourteen years later (1412-13) Delhi was again subjected to a similar visitation, but on this occasion it was aggravated by a drought. There is nothing recorded to show either the extent of the drought or the length of its continuance.

The next in order of date is the famine in the Deccan, said to have occurred about the year 1460, and the memory of which has been perpetuated by a popular poetical legend, known as "Damajee Punt's Akhyan." This famine, which was the result of want of rain, lasted for a year, and is said to have been felt in the Deccan and Southern India.

The Orissa Commissioners of 1867 refer to a notable famine in 1471, but I have been unable to trace any mention of it in the histories of India I have consulted, or in any official reports. As this date falls within the twenty-six years during which the royal house of Jaunpore was contending with Behlol Lodi, it may very probably have happened that scarcity was one of the evils attendant on this protracted war.

About the year 1495 another famine occurred, about which, however, the information available is but scanty. A great dearth is reported to have occurred in Hindustan at this time, but we are told that, all duties being taken off by the king's order, that calamity was in a great measure mitigated. This reference to steps taken by the ruling power to afford relief to the people naturally leads to the conclusion that this was a scarcity of some extent and severity, which may be classed amongst the great famines of India.

A famine of equal extent and duration to that of 1460 is said to have occurred about the year 1520. It is alleged to have been caused by successions of military hordes destroying the crops and plundering everything that came in their way. No measures of relief appear to have been adopted in this case.

The earliest famine in Sind regarding which information is procurable is stated to have occurred in 1527, when Mirza Shah Beg Aghoon conquered the province. Jam Ninda, then ruler of Sind, directed that all grain should be burnt, in order that it might not fall into the hands of the conqueror. This famine lasted for six months.

The next famine occurred in 1540. Mirza Shah Hunun, the ruler of Sind, hearing that Shah Humayún, who had been lately defeated by Shere Shah at Lahore, was about to invade Sind, directed that no crops should be grown on either bank of the river, and he also prohibited the import of grain. This famine lasted three years, and is said to have been particularly severe.

About the year 1554, a dreadful famine is said to have raged in the western provinces of Hindustan, especially in Agra and Delhi, owing to a failure of the rains following upon two years of uninterrupted war. Grain rose in price to two and a half tankas* the seer, and the people perished in large numbers. The common people fed upon the thorny acacia, upon dry herbage, and on the hides of the cattle which the wealthy slaughtered and sold. After a few days, swellings rose on their hands and feet, and they died. The date of this calamity is represented by the words *Khashm-i-izad* or "Wrath of God." The whole country became a desert, and no husbandmen remained to till the ground. Insurgents also plundered the cities of the Mussulmáns.

The year 1577 was one of great famine in Kutch, and even the well-to-do succumbed to its influences. I have, however, been unable to find any details regarding its cause and extent.

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* It is not quite clear what was the value of the tanka in those days.

Owing to a failure of the usual rains, a fearful famine raged over Hindustan in 1596, which is said to have continued for three or four years. The king (Akbar) ordered alms to be distributed in all the cities; public tables were spread, and the army was increased in order to afford maintenance to the poorer classes. A plague also added to the general distress. In consequence of the dearth of grain, and the necessities of hunger, men ate their own kind. The streets and roads were blocked up with dead bodies, and no assistance could be obtained for their removal.

After the country had suffered for two years from a deficiency of rain and famine, a dreadful plague broke out, in 1615, in many parts of Hindustan. It began in the Punjab, and extended through Sirhind and the Doáb to Delhi and its dependent districts, which became reduced to a miserable condition, and many Muhammadans and Hindus died.

A famine occurred in parts of the Bombay Presidency, in the year 1623, when the distress is described as having been very great, and it is stated that the people were driven to cannibalism. In order to afford relief, Lungur-khanas were opened in Ahmedabad, Surat, and Burhánpúr, at which sufficient food was distributed to meet all wants. The famine arose from want of rain, and the ryots, being much distressed, the Badshah assisted them, both this year and the next, with land and money.

The famine of 1629-31 is conspicuous as the first famine in India regarding which any really definite information has been handed down as to the particular districts affected in other parts than the immediate vicinity of Delhi. During 1629 there was no rain at all in some districts, and a deficiency in others. The drought was felt principally in the Deccan and Guzerat, but it is said also to have extended throughout India, and over a great part of Asia. Notwithstanding the liberality of the Emperor (Sháh Jehán), who ordered Lungur-khanas to be established for the poor and destitute, it seems to have been impossible to reach a great part of the distress. Money could not purchase bread, and a prodigious mortality ensued; disease followed famine, and death ravaged every corner of India. For a long time dog's flesh was sold as goat's flesh, and the pounded bones of the dead were mixed with flour and sold. Destitution at length reached such a pitch that men began to devour each other. Those who had sufficient strength emigrated to other countries; and those lands which had been famous for their fertility and plenty retained no trace of productiveness. Taxes of every description were abolished for two years, and 70 lacs of rupees are said to have been so remitted.

Mill, in his "History of British India," states that between 1640 and 1655, a dreadful famine prevailed through India and a great part of Asia, owing to the several successive years of drought, at which time, also, the calamities of war overwhelmed the inhabitants of the Deccan. I have, however, found no reference to this famine in other authors, and therefore imagine that he may have confounded it with the one previously described, owing to an error of date.

A famine is stated to have occurred in Guzerat in the year 1650, of which nothing is known save that it was one of great suffering, lasting over a period of several years.

The famine of 1661 appears to have been both excessively severe and wide spread, and was brought about by a combination of war and drought. In 1659 the movement of large armies through the country during the two preceding years, and a scarcity of grain in some parts, had combined to make food dear. To assist the people, the emperor (Aurungzebe) remitted several tolls, cesses, taxes, and other imposts, to the extent of some crores of rupees; but the orders to this effect seem to have been evaded by the tax collectors. In 1660, the rainfall was also unfavourable, the crops were burnt up, and a prodigious famine prevailed in different parts of India. Many districts lay entirely waste, and crowds of people from all parts made their way to the capital. Immense sums were expended in the purchase of grain, which was resold at less than cost price, while the poorer people were supplied, at fixed places, with a certain quantity free of charge. Other means of supplying relief were also ordered by the emperor, owing to which assistance was carried into every corner of his dominions, whole provinces were delivered from impending destruction, and many millions of lives were saved.

After an interval of about twenty-five years there was a partial famine in the Deccan, owing to a scarcity of rain accompanied by war. In 1686, Aurungzebe was laying siege to Hyderabad, in which city the distress seems to have been most severe. A pestilence also broke out which carried off many men.

In the year 1718, a famine occurred in

Guzerat, known as the "Chowtro." The price of grain rose to four annas per seer. Numbers of people died of hunger and sickness, and children were sold for one or two rupees each. No information is given as to the extent of country affected. It is said that grain was imported from other countries, but it is not clear whether this was a measure of relief adopted by the Government of the time, or a speculation of private individuals.

The spring of 1739 was a time of acute suffering to the inhabitants of Delhi and its neighbourhood, for this was the year of Nadir Shah's invasion, who left a famine in his train wherever he went.

In 1746-47, a great famine visited Kutch and Guzerat. Maha Rao Shree Desuljee was then alive, but the affairs of the Kutch State were conducted by Rao Luckphutjee, who, with a view to relieve the poor of their sufferings, caused food to be cooked in large quantities near the Bid gate, and allowed every one who came there to satisfy his hunger, and to take home with him sufficient food for one other person. This he continued until the rain fell. The following particulars regarding the effects of a famine in Guzerat are taken from the records of a former Padshahee Dewan at Ahmedabad. Few such famines he said, can ever have occurred in which not a drop of rain fell, nor did a blade of grass grow, On this occasion the people turned out for three days to pray for rain, but without effect. A rupee would purchase only three or four seers of grain. The people died in numbers, as did also the cattle. Many ate the flesh of cattle which had so died. Tanks and rivers were dried up. The people in the villages, becoming restless like fish for want of water, left their homes and wandered from jungle to jungle, numbers also going into Malwa and other places. No estimate could be formed of the numbers who perished, and the villages then depopulated were never again inhabited. The rain failed also in the following year.

The Mamlutdar of Purantej, reporting on his own district for the same year, ascribed the calamity to an excessive rainfall. Common grain was there sold for eight or ten seers the rupee, while ghee was even cheaper; cattle thriving unusually well owing to the abundance of grass. Prices remained high during seven years, common kinds of grain never falling lower than twenty seers the rupee. During these seven years the people were free from sickness, which, however, prevailed for two months afterwards, during which many people died. The people were in no way assisted by the Government of the time, and it does not appear that any measures of relief were adopted.

In another account, it is stated that this famine was called *Talotra*, or *Tankia Kal*. In the year 1746-47, the grass did not grow at all for want of rain. The Subedar Jawan Murda Khan went into the jungle with his followers and offered prayers, but without success. Grain was sold at three or four seers the rupee. People ate the roots of trees, plants, and sometimes even dead cattle and human flesh. Wells, tanks, and rivers were without water. Many persons went to Malwa and returned subsequently, whilst others lost their lives.

The drought extended eastward to Rewa Kanta, where, it is stated, hardly any rain fell in the year, and the crops did not ripen. Many people died, but the wild inhabitants kept themselves and their cattle alive on forest roots and locusts, which latter abounded at the time. The drought extended also southward to Surat, and the famine was very severe. Cultivators fled to Malwa for food, but Government called them back, and made remissions of rent, besides giving advances in the shape of *tuccavee*. During this year of great distress, the then Government distributed grain free of charge, notwithstanding which some parts were desolated.

The year 1756 was one of scarcity, high prices, and distress in Rajputana, but further particulars on the subject are wanting.

There was a famine in Sind in the year 1759, which was caused by war, but it was neither severe nor of long duration. It was felt in Guzerat, where the scarcity was due to war, and partly also to a deficiency of rain; grain was sold at one seer per rupee in the Emperor's army, and one and a half seer in that of the Mahratta's. Other people could get two or three seers for the rupee. It is stated that 60,000 men died in the Emperor's army for want of food. No measures of relief seem to have been adopted for the people.

The year 1761 was also one of scarcity, high prices, and distress in Rajputana; but, as in the case of the year 1756, details are not forthcoming.

With the famine in Bengal and Behar, in 1770, we enter upon the period with which commences the history of past famines contained in the Report of the late Indian Famine Commission. Although the account of thi famine given in that report is limited to exactly two lines, details regarding it are contained in no less than seven different histories and reports. But, it may be observed that whilst it was not one of the objects of the Commission to give histories of former famines, the brief accounts given by them of those that have occurred during the past century only has encouraged the belief, if it has not actually given rise to it, that famines in India are of comparatively recent occurrence, following, if not actually caused by (as some would seem to imply), the introduction of British administration. Against these errors it is impossible too often or too vigorously to contend.

The crops are said to have been scanty throughout Bengal in December, 1768, and this was followed by a bad season in the following spring, when a great inundation destroyed the crops on the low lands. The main or late rice crop of 1769 also failed in an excessive degree, owing to the premature cessation of the rains. The first alarm of famine came from Behar, where two bad seasons had been experienced in succession. So early as February, 1769, the Resident in Behar reported very great distress among the ryots, in consequence of long-continued drought; he accordingly found it necessary to make large abatements of revenue. In the autumn the distress became greater, and Government resolved to import rice, for the relief of Behar, from the eastern districts. In northern Bengal also the scarcity was said to be greater than had before occurred within the memory of the oldest men. Grain became so scarce in Bengal that it was found impossible to send supplies to Madras, in compliance with an application to that effect, in consequence of a scarcity prevailing also in that presidency. To prevent hoarding, strict injunctions were published against buying or selling it otherwise than in the public market.

The drought continuing, distress became very severe by 1770, and besides remissions, free distributions of rice were made in certain places. The first deaths from starvation were reported from Behar, in December, 1769. By March, 1770, the whole country became parched up; numbers of people died, and others subsisted on leaves and the bark of trees. In the country the highways and fields are said to have been strewed, and in towns the streets and passages choked, with the dying and the dead. At last people fed on forbidden and abhorred animals, the child on its dead parent, and the mother on her child. Above one-third of the inhabitants, or ten millions, are stated to have died during this calamity.

The last famine recorded by the Padshahee Dewan, of Ahmedahad, is said to have occurred in the same year, 1770. No information regarding it has been obtained from any other source; but, from his description, the country seems to have suffered more from pestilence than famine, and thousands of people died from its effects.

The Carnatic had been devastated by Hyder Ali's incursions in 1780-81, and his ravages had driven crowds of inhabitants from all parts of the country to seek refuge in Madras, at the same time that that settlement was reduced to great straits for food, as the whole country was suffering from a general scarcity. Accordingly, in May, 1781, a "Grain Committee" was appointed to superintend the distribution of grain in such manner "that the stock in hand might not be expended before the month of September, when fresh supplies might be expected." By January, 1782, the pressure of the distress had become much more severe; famine raged in all its horrors, and multitudes were daily perishing from want. A public subscription was raised for the relief of the poor, towards which the Government contributed; and this was the origin of the existing institution for the relief of the native poor, known as the *Monegar Choultry*. The settlement, and the army in the field, were entirely dependent upon the imported rice from Bengal. To relieve the pressure, numbers of people were sent away to the Northern Circars, where they were provided with occupation. Government took the trade in grain into their own hands, and fixed the price at which it should be bought and sold. Matters were now made worse, by a prohibition against the export of rice from Bengal, owing to an uncommon drought in the Western Provinces. The scarcity of grain continued, and the price gradually rose up to the conclusion of peace with Tippoo (11th March, 1784), after which it fell 50 per cent. in value, and Government wrote "there is now such plenty in the bazaars that we do not apprehend any sudden scarcity."

At the same time that Madras was enduring privations and scarcity, Sind was visited by a famine which extended also over the Thar and Parkar districts. This was caused by the burning of crops and the suspension of cultivation during a period of hostilities. There was, at the same time, no rainfall for two years.

In 1783-84, Upper India was again visited by a severe famine, owing to an extraordinary drought which prevailed for two years. The distress also extended to Rajputana and Bengal. All duties were taken off grain; the severest punishments denounced against any who might attempt to obstruct its free transport; an embargo was laid on the exportation of rice by sea, and a grain committee appointed, who were to construct solid masonry golahs to serve as granaries. As the famine increased, death made great havoc, and the administration appears to have been helpless to stem the distress. This famine made a deep impression on the popular mind, and was distinguished by the name of *Chaleesa*. The price to which food rose has been said to be partly conceivable by English readers if they will imagine the quartern loaf at four shillings, and butchers' meat in proportion.

In the year 1787, a failure of rain and famine are stated to have occurred in the Deccan; but I have been unable to trace any confirmation of the event in either historical or official sources of information. The same year was one of most extraordinary and persistent disturbance in Bengal, of a character the opposite of that of drought. From the beginning to the end of the season there was one continued succession of excessive rains, floods, and storms, so that cultivation was rendered almost impossible. In the eastern districts, the inhabitants were driven from their homes, their cattle were drowned, and general alarm and scarcity prevailed. The duties on grain were suspended, and its exportation by sea prohibited. Government imported grain into Dacca to be distributed at cheap rates to the poor. In some parts there was a great mortality. By June, 1788, the distress began to abate.

Seven years had scarcely elapsed since the last famine in Madras, when another serious dearth took place in the northern districts of the Presidency, and the pressure was apparently felt for two years, viz., from November, 1790, to November, 1792. This was caused by a drought. All duties on grain were suspended, and food was gratuitously distributed to the poor in Vizagapatam and Ganjam, whilst, in the latter place, 2,000 were employed on public works, who received their wages in grain from the Government stores. The numbers of people so employed rose to 3,000, at which number it remained for some time. By September, 1793, the distress had considerably abated, and the people were enabled to leave the works and return to their lands and other occupations.

The years 1791 and 1792 witnessed also a very severe famine in the Bombay Presidency extending over Guzerat, the Deccan, and the Concan, throughout which districts there was an unusual drought. This famine was known as the *Surtala*, and the phrase *Surtala no kal* (the season, 47, *i.e.* 1847 Sumvat) became common in Guzerat; it implied scarcity, and was used as a sort of imprecation when too high prices were charged. An almost total failure of rain was the cause of this calamity. Men and cattle died in numbers, and many migrated to Malwa. The price of grain rose from four annas to two rupees per maund, and it is reported that in some instances people sold their children in the extremity of their despair. The Government gave assistance by the distribution of money and the employment of people on public works. In many parts people were reduced to feeding on the leaves and barks of trees, dead animals, and in some instances on human flesh. The deaths in various parts were very numerous.

In the Report of the Commissioners appointed to inquire into the famine in Bengal and Orissa, in 1866, mention is made of a great famine in Orissa in the year 1792-93, but it appears to rest on local tradition only, and no details are given.

In 1802, there was a failure of rain, severe in the Bombay Presidency and in Hyderabad, but partial in the northern districts of Madras; this was followed next year by famine in the former case and by scarcity in the latter. In 1803 a similar failure, but more decided, occurred in the North-Western Provinces, which led to a very serious and widely extended famine in 1804. In Bombay the effects of the drought were greatly enhanced by the ravages of the army of Jaswant Rao Holkar and the Pindaris in his train. In the Deccan the distress was very severe; people ate rotten wheat, leaves, and vegetables mixed with earth; men are said to have destroyed and devoured their infants; little innocent girls were sold for a few rupees to professional prostitutes; high class Hindus ate of the flesh of the sacred cow, and Mussulmans devoured the detestable pig. Thousands died of unwholesome food, and tens of thousands by starvation. Grain was imported by the Government into Bombay and sold at a fixed price to the public, exportation being prohibited; and public works and hospitals were started for the relief of these who flocked into the towns of Bombay and Surat.

In the North-West Provinces the tract severely visited was that known as the Ceded Provinces of Oudh. Here a lengthened drought fell upon a poverty-stricken people, who had but just been released from the yoke of a sovereign whose oppression and tyranny had already brought them to the verge of ruin. Government granted remissions, and made *taccavi* advances to the people; they also offered a bounty on all grain imported into Benares, Allahabad, Cawnpore, or Fatehgarh. By the beginning of 1804 the distress had become very severe, and people began to emigrate. In June and July rain fell again, and prospects appeared brighter, whereupon the emigrants slowly returned to their homesteads, and Government made them large advances for the purchase of seed, and for replacing bullocks and implements, and this enabled many to profit by the favourable season. Altogether, the remissions made amounted to 20,67,000 rupees, and suspensions to 10,14,000 rupees. No information exists on which to form any idea of the number of deaths (which must have been great), the cost of relief to the starving, the probable value of the crops that perished, or of the loss to the trading classes and agriculturists.

In 1806, there was a widespread failure of rain in the Madras Presidency, especially in the tract known as the Carnatic, and in the parts round Madras, though the northern or Deccan districts were less heavily visited. During the winter of 1806, and the early part of 1807, the distress caused by this drought grew to be very severe. Large crowds of emaciated people flocked into the town of Madras, attracted thither by the existence of a charitable institution (the *Monegar Choultry*), and by the hope of obtaining gratuitous help. There was a good deal of discussion as to the proper measures to be taken, some authorities advocating the opening of works to give employment to the people close to their homes, others advocating the importation of grain by Government into the interior; but the mortality among the cattle prevented the adoption of the latter plan. Employment was given to some extent on the repair of roads and tanks, and it was determined to pay the people in money, and not in grain. The Government at the outset declared against any interference with private trade, but in the end they conceived it necessary to purchase, guaranteeing a minimum price to importers; when the famine came to an end, through the plentiful rainfall of 1807, large stocks were left on hand, and had to be disposed of at a loss. The loss of revenue to Government by this famine amounted to 18,49,457 star pagodas. No complete record is obtainable of the number of deaths which took place, but the mortality is believed to have been very serious.

After a succession of two unusually good seasons, the year 1811 set in unfavourably in some of the southern districts of the Madras Presidency, and the price of grain rose considerably. Government exempted from duty all grain imported into the affected districts, but declined to interfere with the ordinary trade channels of supply, or to import on Government account. On this occasion Government sanctioned disbursements on account of ceremonies for rain to be performed in the principal pagodas in Cuddapah. The large stock of grain remaining from harvests of former years greatly mitigated the distress that must otherwise have occurred. Government granted *taccavi* advances, and employed the poorer people on the construction of public works. Many people died, and there occurred a considerable mortality amongst the cattle. The distress continued until the autumn of 1813.

In the same years there was also scarcity experienced in parts of the Bombay Presidency. Marwar was said to have been entirely depopulated in consequence of several seasons of drought. In Kattywar this was the severest famine on record since 1791; men here sold their children for food, and many respectable and well-to-do persons poisoned themselves as a release from the pangs of hunger which they were no longer able to bear; and others died from want of that grain which their riches could not purchase, whilst others deserted their villages and went to more favoured districts. In Kutch the distress was almost equally great. Both from here and Guzerat numbers of people emigrated to Sind. The Bombay Government refused to import or otherwise interfere with the ordinary grain trade; they gave *taccavi* advances, and commenced some public works for the employment of the poor. The same years witnessed also a partial failure in parts of the North-Western Provinces, but it does not appear to have been very serious there.

In 1819-20 there was again a drought and scarcity in several districts of the North-Western Provinces and Bombay, but it was not very severe, and can hardly be considered to have resulted in a famine.

In 1820 there appears to have been a very severe famine in Upper Sind, caused by an extraordinarily high inundation, which washed away all the crops in the district. The Amirs met the distress by throwing open the Government granaries, selling grain at reduced rates, granting remissions of revenue, and making advances on liberal terms.

There was a general failure of rain in the autumn of 1823 in several districts of the Madras Presidency and Mysore, which caused the price of grain to rise to double its usual figure. Inducements were held out to merchants to import grain from Bengal; advances were made for the construction of wells, and orders were given for the employment of people on public works. Numbers of poor flocked to the presidency, where a serious grain riot took place. Establishments were erected for feeding them under the management of a local committee. In 1824 the famine increased, and deaths from starvation became of frequent occurrence. The loss to Government caused by this famine through decrease in collections in different branches of revenue amounted to 34,64,000 rupees.

There was a severe drought in parts of the North-Western Provinces in 1824-25, and in the following year it extended over an increased area. The consequent scarcity was increased by the fact that the existing settlement being on the point of expiry, the landlords were lessening the cultivation on their estates and rack-renting their tenants, in the hope of a reduction of *jumma* on re-settlement. The distress, however, does not seem to have been very great, and no measures of relief seem to have been necessary beyond comparatively small remissions and suspensions of revenue, and liberal advances.

In the same year, 1824, there was also a drought of long continuance in the Bombay Presidency, particularly in the Deccan and in Western Guzerat, and serious apprehensions were entertained of a scarcity or even famine. The export of grain from the affected districts was accordingly prohibited, and measures were directed to be taken for digging wells wherever it could be done with advantage. Numbers of people flocked to Bombay in search of food, and it became necessary to commence the construction of public works in order to find them employment. The following year was also unpropitious, but the distress does not appear to have been very aggravated.

In 1827, there was also a scarcity in the Saugar and Narbada territories, brought about by blight and excessive storms, which beat down and destroyed the crops. In the same year there was a drought beyond the Jumna, in parts of the Hissar district.

The Madras Presidency was the seat of the next great famine—that of 1833, though, on this occasion, the northern districts suffered most, and especially the Gantur district, in which the mortality was so terrible that this was known as the Gantur famine. On this occasion the Government appears to have been taken by surprise, and the severity of the calamity was not recognised till too late. Very little was done to relieve distress, except by the gratuitous distribution of cooked food in the towns to which the sufferers flocked. It was estimated that 200,000 persons died in Gantur out of a population of 500,000. The adjacent parts of Bombay, Mysore, and Hyderabad, also shared in the calamity, though to a lesser degree. There was also a drought, the same year, in the North-Western Provinces, which produced scarcity but not a famine.

After a succession of indifferent seasons since 1832, a serious drought in 1837, over nearly the whole of the North-Western Provinces, caused one of the severest famines since the beginning of the century. Considerable grain riots occurred in various parts. Wherever there was a large demand for employment public works were ordered to be opened, and at the same time relief committees were formed, and subscriptions invited to feed those who were unable to work. Remissions and suspensions of revenue were freely granted, and the former amounted to 95,000,000 rupees, or nearly half the land revenue demand in the affected tract. The deaths on this occasion have been estimated at 800,000, a figure, however, which is believed to be considerably under the mark. The extremity of suffering, endured by the population, was such as to leave behind a widespread and lasting recollection of the horrors of the famine; and it was some years before its effect ceased to be legible in the lessened figures of the land revenue.

In 1838, considerable distress appears to have prevailed in the provinces of Kutch and Kattiwar, owing to scarcity of food, but there are no records to show what measures of relief were adopted by the native Governments. Numbers of families emigrated in search of food, and upwards of two thousand souls took refuge in the Bombay Presidency, where employment was found for them on the roads and other public works.

Though occasional partial scarcities occurred in some localities, between 1833 and 1854,* it was not until the latter year that any district of the Madras Presidency was again visited by famine, and then it was fortunately almost entirely local in its effects, being principally restricted to the Bellary district. Owing to drought the harvest did not yield more than half an average crop, and prices were double the usual rates. It was accordingly found necessary to give employment to the poorer classes to save them from starvation, and at one time 97,000 people were so employed. There is no definite information as to mortality among the people, but four-fifths of the village cattle are said to have died. The expenditure on relief works amounted to about 16 lacs, and the loss of land revenue and other income 42 lacs of rupees.

The seasons immediately following the Mutiny were unfavourable in the North-Western Provinces, and in 1860 the monsoon was so indifferent that the autumn harvest was to a great extent lost. The winter rains also were entirely wanting, and a severe famine was consequently experienced, chiefly in the country between Agra and Delhi. About half a million of people emigrated. Government opened ten large relief works, and minor works were started for the employment of those unable to travel. Altogether about 12½ lacs of rupees were so expended, and some 35,000 persons employed daily for a period of ten months on these works. Gratuitous relief was also given to about 80,000 persons daily for nine months, at a cost of about 14 lacs of rupees. Although no facts as to the numbers who died in this famine are available, the mortality was no doubt excessive, and has been estimated to have reached 200,000, or about 8 per cent. of the population of the parts mostly affected.

The drought of 1865 was felt along the whole eastern coast of India from Madras upwards, and it extended to some distance inland, visiting Mysore, the districts of Madras above the Eastern Ghâts, Hyderabad, the hill-country in the south-west of Bengal and Behar; but it was most intense along the coast in the districts of Ganjam and Orissa. In the following year the rainfall was also late and deficient, and prices rose to an extraordinary height. In Madras, assistance was afforded by relief works, relief houses, and the gratuitous distribution of cooked food. The drought fell with far greater intensity on Orissa, but the depth of the calamity was not realised till suddenly the province was found to be almost bare of food. Owing to the monsoon and the want of communications by land, it was next to impossible to import food. By great exertions and enormous cost, Government threw in about 10,000 tons of food, which was given away gratuitously, or sold at low rates, or distributed in wages to the starving population, but the relief came so late and the distribution was so ineffective, that nearly a third of the population, or about one million persons, died. The following year was also a disastrous one in Orissa on account of floods. The total amount spent by Government in this Orissa famine was about 14,500,000 rupees.

In Behar also it was necessary to start relief works, and make a gratuitous distribution of grain. There was no record of mortality kept, but the police reported that about 135,000 persons died of starvation and of diseases arising from want.

A year after the cessation of the above-mentioned famine, the rains failed again over the greater part of Western and North-Western India, and the drought was followed by one of the most widespread and grievous famines on record, extending as it did over Rajputana and Central India; great parts of the North-Western Provinces and Punjab, as well as parts of the Central Provinces and Bombay. Enormous numbers emigrated from the native States affected where no system of relief existed, and this aggravated the evil in British territories where the ordinary systems of relief were speedily established. Great numbers are known to have died from starvation and disease, but owing to the imperfection of statistics at that date, the actual extent of loss of life from these causes cannot be stated.

In 1873, the rains in Northern Bengal and parts of the North-Western Provinces and Oudh failed, and it became necessary to adopt the ordinary means of giving relief to the suffering population. About 340,000 tons of grain were disposed of in the relief operations in Behar alone, where the cost of the measures adopted by the Government reached 6½ millions sterling, or as much as the total expenditure on all past famines in all parts of India from the beginning of the century to that time. The result of the inquiries specially made on the subject was to indicate that no mortality whatever was due to the famine.

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* In 1845, great distress arose in Candeish. It lasted only a short time, but such were its effects that fears were entertained regarding the preservation of the public peace. This distress was the result, for the most part, of a combination among the grain dealers, who would not bring sufficient grain into the market, though there was no scarcity of it, their object being to reap as large profits as possible at the expense of the poorer classes.

The great famine in Southern India of 1876-78, was, in respect of the area and population affected, and the duration and intensity of the distress, the most grievous calamity of its kind ever experienced in British India since the beginning of the century. The failure of the rains extended over about half of the Madras Paesidency, nearly the whole of Mysore, the southern half of the Hyderabad State, and all the Deccan districts of the Bombay Presidency. At the same time the registered rainfall in part of the Central Provinces, in the North-Western Provinces, and in part of the Punjab, was less than any ever before recorded. The calamitous season of 1877 was accompanied by an extremely high range of prices all over India, due partly to the deficient harvest, and partly to the reduction of the food stocks through export from the Northern Provinces to the south and to Europe. These causes prolonged the distress in Madras, Mysore, and part of Bombay over a second year, and created great suffering among the poorer classes in the Upper Provinces. The principle laid down by the Supreme Government for adoption was that no efforts were to be spared "to save the population of the distressed districts from starvation, or from an extremity of suffering dangerous to life," but not to "attempt the task of preventing all suffering, and of giving general relief to the poorer classes of the community." "Everyone," it was said, "admits the evils of indiscriminate private charity, but the indiscriminate charity of a Government is far worse." Extraordinary measures were adopted with the view of meeting this unprecedented calamity. The average number employed daily on relief works was 877,024, whilst 446,641 were in daily receipt of gratuitous relief, involving, together, a cost to Government of 2,08,49,200 rupees; whilst the loss in land revenue amounted to 193,60,000 rupees. The total cost of this famine to the State was no less than 11,19,43,200 rupees. The Famine Commission estimated that during the famine, on a population of 190 millions, the mortality in two years was 5¼ millions in excess of the deaths that would have occurred had the seasons been ordinarily healthy. This figure, of course, includes not only deaths from starvation, but also from fevers and other diseases which ordinarily attack systems weakened by long periods of insufficient or unwholesome food.

With this, the last and most dreadful calamity of its kind that has visited India in recent years, I close my record of drought, dearth, destitution, disease and death. What must have been the consequences had India, during the past century, been under native government, little advanced in civilisation beyond what they were one hundred years ago, and possessed of none of the modern means of communication, if visited by such calamities as I have just recorded, may be to some extent realised, if the fact be borne in mind that even so recently as 1865 no system of relief was afforded by the native States then visited by famine. If, with all the wealth and resources of Western civilisation, it has hitherto proved impossible to do more than mitigate the evils of famines, some conception may be formed of the horrors that must have accompanied such visitations under native administration, when the country was almost destitute of means of communication. It cannot, perhaps, be expected that India will cease to be visited by these periodical droughts which have been the main cause of such famines, but, under the present system of government, each year will find the country better prepared to meet such emergencies, by the extended mileage of her railways and increased area brought within the means of artificial irrigation, by which certain areas may be protected from drought, and greater security from its effects afforded to others; whilst the means of rapidly conveying the surplus crops of one district to another will tend to check any sudden and abnormal rise in prices, and enable the ordinary trade channels better to supply the wants caused by local failure of crops than has heretofore been possible.

What has recently been effected in India, owing to British administration, has made that country one of the greatest marvels of the present century. In an almost exclusively agricultural, and, therefore, a poor country, within the past half century, upwards of two hundred millions sterling have been spent on railways and irrigation works. The railways completed or under construction amount to no less than 15,000 miles, that being in excess of the open mileage in Russia, and exceeded only by the United States, France, Germany, and the United Kingdom. And withal India remains still the lightest taxed country in the world.

The labours of the late Famine Commission have resulted in the establishment of a code of rules adapted to meet the circumstances of various degrees of scarcity or famine, by which the administration will be guided in future emergencies. The advantages of a settled line of policy at the commencement of a famine cannot be too strongly insisted upon; these have now been ensured, and every year that the next visitation is deferred will find the country better prepared to cope with it, until the time shall arrive when, by the existence of a perfect system of internal communications and the fuller development of the resources of the country, all that human art can accomplish shall have been done to avert the possibility of such occurrences as have happened in the past, when a hope may be fervently expressed that famines may become as rare in British India as they have, happily, now become in Western Europe.

DISCUSSION.

General **Rundall**, C.S.I., said that, were it not for the concluding sentences, in which were enumerated what had been done by the Government towards averting these calamities, one would scarcely know how to discuss this paper, which was characterised by the lecturer himself as a melancholy record of drought, dearth, destitution, disease and death, and of which the last-mentioned case was the worst of all. He was rather surprised that Mr. Danvers had not gone into the question of the policy pursued by the Government with reference to works for averting famine, but he could understand that, from the position he held in the India-office, it might perhaps have been not quite in form for him to have entered on a discussion of that kind. Not long ago, he was present when a paper was read in another place on water storage and canals in India, and how far they were preventative of famine, and he said he wished that that paper had followed this one, because it would have shown in what degree the Government had succeeded or failed in its duty towards the country. Having been an eye-witness of more than one famine, and during the greater part of his Indian career been engaged in designing or superintending works for averting famine, he might say a few words about what had been done. His instances would be taken from the Madras Presidency, where the last and greatest famine had occurred. The total sum expended on irrigation works throughout India was £24,500,000, while in the Famine Commissioners' Report the total loss the Government had sustained in successive famines was stated as £23,500,000. The irrigation works, after paying the interest on the total capital expended, returned upwards of 5 per cent., but the sum spent, and hopelessly spent, in trying to mitigate famine returned nothing, and 10,000,000 of lives were lost during the century. According to the official reports, the Godavery works, after 35 years, had netted £1,400,000, or double the whole capital outlay; the Kistna works, after 25 years, had netted £281,000, which was perhaps half of what they had actually cost; and these two works irrigated 563,700 acres and 303,000 acres respectively. The Tanjore works were yet more remunerative, but he would not say more about them, as they consisted rather of improvements on existing works founded by the native Governments, and it might be a question what those had originally cost. In Behar, the Punjab, and the North-West Provinces, all the irrigation works had prospered more or less, but he must not forget to mention those which had not been prosperous. Two especially were always brought forward as failures, the Kurnool works, and those in the province of Orissa. He was responsible for the latter, and could only say he was sorry the Government had not reaped the interest on their money; but so far as the people were concerned, the works had not been a failure, for the country had been, to a great extent, preserved from future famine, provided with cheap water communication, the revenue was easily collected, and the exports had risen from £60,000 a year to £1,500,000. The expenditure on the Orissa works was just equal to the outlay incurred in the great famine, which was powerless to save 800,000 lives. In speaking of irrigation schemes he did not mean simply the supply of water for agricultural purposes; they also comprehended protection from floods, drainage, and above all, water transit. This last item was of the utmost importance. Mr. Danvers had spoken of the 15,000 miles of railway in India. They had unquestionably rendered great service, for they had been constructed cheaply, were worked still more cheaply, and the rates were in some instances very low, as low as $\frac{3}{8}$ of a penny per ton per mile for minerals; but considering the enormous distances to be traversed in India, that was not sufficiently low to ensure the transport of bulky articles of small value. One important question in connection with famines was the loss of cattle, which meant diminished power for agricultural purposes for the next season. Whatever the railways might be able to do in the transport of food for human beings, he questioned their capacity to carry food for cattle. This last necessity was an argument for increasing the outturn of food in every province where it could be effected, and also for providing additional means of transport of the cheapest character. He hoped that more attention would be given to the establishment of new lines of water carriage, and to the perfecting of those which already existed, so as to make them not merely isolated schemes, but links in one grand line of communication.

Mr. J. GIBBS, C.S.I., said he was a member of the Government of Bombay during the famine of 1876–7. At the beginning of that famine they had to fumble in the dark, having no fixed rules to go by; but as time went on they saw their way pretty clearly, and all who were engaged in the work were pretty well agreed on the rules to be laid down for guidance in future. The question of irrigation *versus* railways had been fought out very ably on both sides, and having gone over it himself to a certain extent, he had come to the conclusion that no system of canals could take the place of railways in transporting food from one part of the country to another. At the same time, irrigational works were equally important locally if not nationally. In a country like the Deccan, for instance, wherever a large storage of water could be secured so as to make the flow in the canals perennial, they should be extensively adopted. But it was on railways they must chiefly depend for moving grain from one part of the country to another, whilst a system of canals should be carried out to turn the dry and unproductive parts of the country into good arable land. Another question of considerable importance was, what was the duty of the Government with regard to supplying the people with food. In the Bengal famine of 1874, the moment scarcity was reported the Government set to work buying grain right and left, and sent it all over the country, buying also large numbers of ponies, camels, and even elephants to carry it. At length, when the famine ceased, there was a large stock of grain lying rotting, and a large number of animals who were of no use except to eat the grain. When the famine broke out in the Bombay Presidency, certain experienced officers again urged the purchase of grain by the Government, but he was one of those who took the opposite view, and considered that the right course was to give every assistance to the railways to enable them to carry the grain, but to trust to the merchants to supply it. This course was adopted, and turned out to be the right one, and the trade supplied all the food that was wanted. But that was not so much a famine of food, it was a famine of money. He was of opinion from the beginning that public works, at which people could earn money to buy food, were required more than food itself. The great difficulty was to find employment for the people. One party were anxious that there should be a number of small works round the different villages, so that the people should not have to travel to a distance, and in one or two places it went to the absurd extent of a suggestion that one set of people should dig holes along the side of the road, and another set should fill them up again. He and some others, however, thought that such works could not but have a demoralising effect, and urged the importance of having large works of public utility undertaken. Fortunately, there were in the Public Works Department many excellent schemes both for canals and railways, and after much pressure some of them were commenced, one particularly, a chord railway which avoided going down one set of ghauts and up another, in the transit from Calcutta to Madras. All the earth-work on that line was made during the famine. Several large tanks, and one or two canals were also undertaken. There was another important point. It was very difficult to manage the population of India, who were quite unlike the labourers of this country; they were callous of life, and would rather lie down and die than take a little trouble. For instance, a woman was found at the roadside, almost at the last gasp, and though taken into the hospital and cared for, she only lived two days. On her was found, afterwards, a bag with 16 rupees, showing that she could have supported herself well for some time to come. Other cases of a similar kind could be quoted, and it became a question whether the people should not be treated more as children, and be taken to work. In his opinion, founded on his own experience, he thought it was justifiable, and often the only way to save their lives. It might savour to people here like an interference with the liberty of the subject, but to his knowledge it had been done, and successfully, and it seemed to him preferable to letting them lie down by the side of the road and die.

Sir WILLIAM R. ROBINSON, K.C.S.I., said he would not attempt to follow the previous speaker's confessions, as to the authorship of much which he could not recall to mind without a feeling of the deepest pain and disapproval. Results, he held, did not testify in favour of any management of famines on those lines. He rose with another object, however. He should like to ask General Rundall whether there were any statistics showing to what extent the districts of Tanjore, Kistna and Godavery assisted in feeding the population of other districts which were not irrigated. He did not recollect that much grain was sent from these irrigated areas into non-irrigated districts; his impression was that they were almost entirely dependent on rail-carried grain. Even irrigated districts do not, under conditions of real famine—drought—do much more than support their own people.

General RUNDALL said he could not answer the question with authority, but a reference to the trade returns from the Godavery district for the years in question would show whither the grain was carried. There was a large export of grain to Madras from the Godavery district, and a surplus, though not so large, from the Kistna.

Mr. MARTIN WOOD said there were no exact statistics on this point, but he remembered an officer who had travelled through the delta districts testifying to the considerable surplus they enjoyed, by which not only was the population proper kept in good condition, but also thousands who flocked in from elsewhere, and large sums were expended on building works which they had been waiting to do for years. He had witnessed several of these famines, and felt a strong interest in the subject, but it was much too large a one to be thoroughly discussed then. There was a good deal of ancient history in the paper which was made more interesting by the diagrams, but still he thought there were some gaps which might perhaps have been filled up. He happened to call at the Poona Duftar when the inquiries were first made into past famines. Colonel Etheridge, who was asked to make the report, was at a loss how to begin, but, as a Hindoo official suggested, the first thing to do was to look at the records and see when there had been large remissions of revenue. Mahratta accounts were all kept very fully, and no doubt in that way valuable information could be obtained. The only part of the paper which invited discussion was the conclusion, where the author asked, "What must have been the consequences if India during the last century had been under native government?" and so on. He did not think that this general rhetorical way of treating the matter was conducive to sound conclusions; it was really to a large extent begging the question. Mr. Danvers stated that in the native States there was no system of relief, but yet in the earlier part of the paper, in nearly every instance of real famine, it was recorded that relief was afforded. It might be in a clumsy rule of thumb way, but it was evident that the native rulers did exert themselves to relieve those famines. It was to be noticed that in many of these instances the writer had not discriminated sufficiently between famines and devastation caused by war. The subject of famines might be divided into two parts—the cause and the means of mitigation. The cause of famine, allowing for exceptional instances of floods, where the crops were washed away, was—drought. It might be said that this was the natural result of the climate and situation of India, and that you could only take measures to relieve it when it came. But he did not agree with that indolent way of looking at the matter. It was remarkable that in all those parts were the rain was most scanty, the population had provided against it by irrigation. Of course they could only do so where the means were available, but that applied exactly to the case of Sind, where, though there was no rain, there was no famine. Coming eastward you came to the great desert, which some regarded as irreclaimable; but it should not be beyond the reach of modern science to make Rajputana and even the great desert comparable to Sind. A general argument was deducible from that single instance; the drought was combatted in those particular districts; famine was caused by drought, and the way to meet it was to supply the want of water. Now, taking the whole surface of India, there was enough and more than enough water to meet the devastating drought which must come at times. Of course this question included the very serious one of re-afforestation. With regard to the mitigation of distress, they had heard of some of the difficulties, and that brought it back to the great question whether it were better to afford substantial, permanent mitigation, or the temporary mitigation afforded by railways. There was the contrast. By railways you could take grain from one part to another when the people were starving; but how incomparably better it would be to provide by other means that in no part of the country should this excessive destitution occur. That he contended was perfectly practicable. Not one-fourth of the amount expended on railways had been applied to the distribution of water. He feared that people in England, where the distances were so small, and railways were so thoroughly developed, did not realise the immense difference of conditions in India, and understand what railways could do, and what water could do, over such distances. With regard to the contrast between ancient and modern times, he would point out that during the period of about 1,500 years—between 400 or 500 B.C. and the Mohammedan invasion—there were scarcely any records of famine. This was accounted for by saying that the historians of those days were more accustomed to record the doings of emperors and armies than the social condition of the people. But just before that period there was an instance of a famine being recorded, and one immediately after it, so that he thought it must be assumed that, if ever there was a golden age in the history of India, it must be that time. Coming to more recent times, there was again a great contrast. In the fifty-two years ending 1854, there was a record of thirteen or fourteen famines, with a probable loss of life of five millions; but in the period of only eighteen years—from 1860-78—there were sixteen famines, with a loss of life of nearly twelve millions.

SIR JULAND DANVERS, K.C.S.I., said the last speaker appeared to complain of the historical character of the paper, but he thought the public were indebted to any one who would give the history of the past on any subject, for it was only by a wise consideration of the past that we could be guided for the future. Although the writer very properly refrained from going into the question of policy, the meeting was not precluded from discussing it. It seemed to him that neither railways nor canals should be exclusively looked to, but the two together ought to make famines almost impossible in the future. With proper organisation, a suitable system of railways and canals, and an improved method of fertilising the land, it would yield much more than it would produce otherwise; and provision could be made not only for ordinary times, but for famine when it occurred. It was a curious fact that two or three famines generally occurred in successive years. He did not think any periodic law could be laid down, but the longer they had been without a famine the nearer probably they were to the next; therefore precautions should be taken in due time, and with the means now available this could be done with a great assurance of success. The Government were now sensible of the importance of both these works, and were anxious to extend in all directions the means both of communication and irrigation. There were places in India which even in ordinary times were over-populated, and did not provide the means or life for the inhabitants; but by means of education and railways it was not impossible that that instinctive dread of leaving their homes which the natives possessed would be overcome, and they would see the necessity of migrating to other parts where they could find employment and food. By cultivating more land, exports would be able to be sent to this country and to Europe. Trade would improve, the whole country would become more wealthy, and such a change would be introduced into the social condition of the people that they would not only become free from famine, but altogether an improved race.

Mr. W. G. PEDDER said he spent a great part of his time and service in India in the province of Khandeish, which suffered as much as any part of the Deccan from the famine of 1802. That great famine so completely devastated the province, which was before extremely prosperous and fertile, that to this day it had not entirely recovered. Some parts were still covered with jungle, hiding the remains of old towns and villages which had never been inhabited since 1802. Compare that with the famine of 1876-8. No one who was in India at that time but could testify to the fearful sufferings of the people, but in two years scarcely any traces of the calamity were left. He himself was in charge of a district which suffered severely, but after five or six consecutive good years the traces of famine had entirely disappeared. This was shown from the stock returns which, as had been already pointed out, were very important. Stock was lost in very large quantities, in some parts half the stock died, and the other half was only saved by being driven away to distant forests, but there was now 15 or 20 per cent. more stock than before the famine. That showed the strong recuperative power which there was at the present time. They knew very little about these old famines, but as far as he had seen of the old records, the general form of statement was that grain rose to so much; and in fact, at the present time, the Government looked on an extraordinary rise in the price of grain as the principal indication of a famine. It appeared that in some famines the price rose to 4 annas the seer; whilst in the bad famine of 1791 it is stated to have risen only to 2 rupees a maund, or 1 rupee for 20 seers. We really knew very little about prices in India, but it was a subject which well deserved attention, and he hoped some competent person would take it up. He would point out, with regard to irrigation, that there were some parts of India where it would be practically useless as a safeguard against famine. No one was a greater advocate for irrigation where practicable, but the instances adduced by General Rundall were those connected with the Ganges, and in the north-west, which being snow-fed from the Himalayas, were absolutely secure from failure of supply, or those in the deltas of Madras, fed by the large rivers Godavery and Kistna. In the parts with which he was best acquainted, the Deccan and Central India, there were very few such rivers; the irrigation works there, which were very useful in many respects, were fed by small rivers or tanks. When it rained these sources were full, but they did not want the water; when it did not rain the rivers and tanks were empty. It would be unwise, therefore, to lay down that famines could be entirely prevented by unlimited works of irrigation. On the other hand, experience taught that the whole of India never suffered from famine at one time, and with railways and sufficient means of communication the surplus grain from one province might be taken to feed the starving population in another. He was afraid Sir Juland Danvers was too sanguine when he said famines would become impossible. Anyone who had been in India in a famine year, and seen day after day and week after week the heavens as brass and the earth as iron, and a burning sun instead of fertilising rain, and that an enormous proportion of the crops must be ruined, would feel that it was too much to hope to ever abolish famines.

Surgeon-Major PRINGLE said the last time he met General Rundall was in Orissa, where he was engaged in the construction of the Orissa irrigation canals, and he was pleased to hear of the benefits derived from them. There was a statement in the paper that when the famine occurred it was discovered that the stores were empty. Of course they were. How was it possible in India, except in large towns like Calcutta or Bombay, for the district officer to know what the stores contained. He could not get at the truth from his subordinates, for some of them were grain merchants. The fact was, the whole of the grain was being sent out of the country for some years previous to the famine. He was in Orissa in 1855, when a million maunds of grain were lost by floods; but nobody felt it, and a few years after a large export trade took place, and thus any one could see what the famine was due to. The people lived for years on the Sumbulpore rice that came down the river. On one occasion they got such prices that they even drew on their seed rice—it was anything for money—and after paying debts, it all went on the women's arms in bangles. When the Sumbulpore rice failed, and the country was dependent on local supplies, then the inquiry was—where are the stores of grain? They were all in the French market. Sir Cecil Beadon incurred much opprobrium on account of these empty stores, when he had no more to do with them than the Governor-General. With reference to irrigation, he knew nothing about the Godavery, but he knew a great deal about the Ganges, and he thought the subject would soon have to be brought to the notice of the public. It was all very well to talk of the benefits irrigation conferred, but there was such a thing as paying too high a price for them, as would be seen when the death rate of the countries on the Ganges canal was told, and when they heard of the population being decimated in certain localities, and the land in some places absolutely rotted. In the Derbund Doab there was not till lately an acre of irrigation except from wells, and this district for twenty years knew nothing of famine, and the death-rate was remarkably low. The deaths from famine were not to be compared to those from pestilence. In four districts, with a population of 4,000,000, 400,000 people were carried off, and last year 200,000 died from small-pox in the North-West Provinces and Oudh. People had no idea of the density of the population in some parts of India, 500 to the square mile. How were they to live if sickness or scarcity occurred? Naturally, the deaths would be enormous. He had never before heard the expressions a famine of money and a famine of food, but he could understand them, and the full depth of their meaning. The famine in Orissa was one of food, but there was, comparatively speaking, lots of money. In Bengal there was a famine of money; the people could not buy what they wanted, and had thus to be fed. If a time were to come when there would be no more famines, they would have to alter the metereological arrangements of one of the most extraordinary countries in the world. On the 10th October, 1877, a shower of rain fell over an expanse of country of nearly 600 miles square, and thus saved the crops over the whole North-West Provinces and Oudh, part of the Punjaub, and the Central Provinces. It was almost impossible to explain what a good crop in India was. You saw a man scratching on what looked like a sand-hill, and putting in wheat, and if it were a good season, that barren-looking place produced the most luxuriant crop. Then the storage of grain had been referred to; very few knew how utterly useless the best harvest was unless it could be stored. He had seen grain almost given away because the rain was so great it could not be stored on account of the dampness of the air, and the damp condition of the ground. In 1883 there was one of the finest crops ever seen—enough to feed the people for two years without the sowing of an acre—and it was a splendid season for storage, but the railway carried away all but enough for immediate wants.

The CHAIRMAN, in proposing a vote of thanks, said the great value of the paper was in its being so far-reaching. It had gone over a very large space of time, and had shown the fallacy of the idea, which had become pretty general in England, that famines in India were, in some way or other, the result of British rule. It had been shown that they had extended over many centuries, as far as records could reach, and that they were due to climatic conditions which were unchanging and unchangeable. In this respect the paper conveyed a warning, for it showed that famines must be expected to recur probably at frequent intervals; it also gave a warning against drawing rash conclusions from recent statistics of famine. One speaker had remarked that Anglo-Indians were rather too optimist in the views they took of the results of our administration of that country, but he did not think that was a charge which could be reasonably brought against them. In his view they were rather inclined to criticise a little too freely; in fact, we were far too conscientious in our administration of our dependencies abroad for our own comfort and reputation. There existed in British dependencies a class of critics not to be found in the dependencies of other countries. Russians, Italians, and Frenchmen were always eager to speak up for what they considered the honour of their country, and to conceal any little weaknesses of administration; but there was a class of critics in India who seemed to take a perverse delight in running down the administration of their own countrymen, and contrasting it unfavourably with that of the native States. These gentlemen seemed to forget that the science of comparative statistics was a modern invention, and that such an indifference to human life existed in all Eastern countries up to a very recent time, that it was impossible to get any accurate knowledge of the loss of life caused by famine in former times. Now, on the contrary, everything was most carefully tabulated, and there was a keener sympathy with human sufferings, and a higher conception of the duty of the State towards the people who suffered in times of famines, and, therefore, the calls on the administration in these days were very much greater than they had ever been before. All these things ought fairly to be borne in mind when people came forward and furnished statistics of the enormous loss of life in recent famines. They knew how often bad years followed one another successively, for we had had recent experience of the same thing even in England. So in India there was a period of 15 or 20 years during which there were frequent famines, but now for a period of 8 years there had been none. It was exceedingly misleading, therefore, to take a short period and say—Look at the great loss of life in that time, it must be the result of bad administration. He was not there to apologise for all the mistakes which might have been committed by the Government of India, but he should like to point out what seemed to him the principal cause of such loss of life as took place during the terrible famine of 1876-8. During the Bengal famine in 1874, a very large sum of money was needlessly—as was now admitted—expended for the prevention of suffering by famine. Many people seemed to think the State had an unlimited treasury — some fund of its own into which it could dip its hand and take the money out. But the State had no money except what it took out of the pockets of the taxpayers, and its most sacred duty was to consider their interests. If it spent money too freely in the relief of distress or on public works, it naturally had to increase the taxation of those who were able to pay it, and so the suffering was distributed throughout the population in another way. If the Government of India had in 1876-8 spent money as freely as it did in 1874 it would have been compelled to impose very heavy taxes on the people, and the very men who came forward and said how scandalous it was that lives were not saved, would have said what an inhuman thing it was to place such burdens on the people. It was this excessive regard for the interests of the taxpayers which perhaps led the Government of India at that time to take too narrow a view of the duty it owed to the suffering people throughout the country. But there were other considerations to be taken into account. During a long period of peace and settled Government the population had greatly increased, and when a famine overtook a large extent of the country, there were enormous masses of people who were perfectly helpless, who would not move from their own doors, and whom it was almost impossible for the most energetic Government to relieve, so that there should be no loss of life. It was quite possible that to some extent the Government in 1876-8 failed to overtake that calamity as it would have wished to do, but this was far from being due to any want of good intention, or of sympathy with the people. The work of the Famine Commission had been done most thoroughly, and he did not believe that whatever famines might hereafter occur, they would not be able to cope with them successfully. During the discussion there had been a repetition of the old feud between railways and irrigation works. People in India not being divided into political parties, were apt to take sides about questions of public works; men who believed in railways would not admit that there was any good in irrigation, and on the other side, men who thought irrigation valuable, said railways were only a costly nuisance. There was a good deal of exaggeration on both sides, and Mr. Pedder, than whom no one was better able to speak on this subject, had put the case very fairly. Railways and irrigation works were both very useful in their way. Mr. Martin Wood remarked that railways were only of occasional value, when famines broke out, in bringing food into certain districts, whereas irrigation works were of permanent value, but that was not a fair description, for wherever railways went there was a belt of cultivated country along the track, and that belt was continually increasing, and more land being taken into cultivation. He felt convinced that whatever had been the case in the past, the Government of India now had not only the desire, but the requisite knowledge and means for preventing the famines which would occur, from being as disastrous in the future as they had been in the past.

The vote of thanks having been passed,

Mr. DANVERS, in reply, said he did not think he had omitted any famine from his list which was recorded anywhere. He had not omitted the question of policy because he was in the India-office, but simply because the policy of the past was a thing of the past; and since the completion of the labours of the Famine Commission, which had resulted in the laying down of rules for administration in future emergencies, there had been no famine, and therefore there had been no opportunity of testing the value of those rules. There had now been eight years without famine, and during that time great progress had been made in public works of all kinds, which he held must be of immense value if another famine occurred. He had no intention of putting forward an optimistic view of the situation. With the extension of railways it would always be possible to throw grain into distressed provinces; and although drought and consequent distress, to a certain extent, could not be avoided, yet he hoped the dreadful results which had happened before might be considered a thing of the past.

Mr. HYDE CLARKE writes:—As several gentlemen of Indian experience were called upon to speak on the 19th inst., which left me no opportunity, I beg to offer a few remarks on matters which come within my scope of observation. First, with regard to the criticism on the list of ancient Indian famines, given by Mr. Danvers. In so doing he rendered a material service, and supplied us with a chief element for determining what have been the climatic and economic conditions of the country in all times. I state this because I differ from him in his remarks on the "sun-spot" law. As is known, the short period of 10-11 years was discovered by myself, afterwards it was seen that it coincided with the "sunspot" period observed by Herschel and others, and the notion of the "sun-spot" period being a cause instead of a concurrent effect, seized hold of the minds of men of science and the public. Professor Stanley Jevons was struck by remarkable coincidences in prices at Delhi, and he was led into expressions of great enthusiasm. At the time of his unfortunate death he had, in correspondence with me, arrived at a greater agreement with regard to the phenomena. My results were based on the weather phenomena, but particularly in reference to their effect on the crops. They were obtained from the data with regard to England since A.D. 1000, and a comparison with similar data for France and other countries. Therefore they cover the latter period of Mr. Danvers's from that time, and throw light on his materials. My data may be usefully collated with those given by Prof. Thorold Rogers in his laborious history of prices. Now, so far from there being no law on the subject, we have ample materials for ascertaining the history of the meteorological conditions of the globe. In a general sense, the phenomena are uniform in their general character n all observed epochs, and, it is to be inferred, in all time. They are, however, subject to fluctuations evidently under the influence of cosmic laws. One of these produces the short period of 10-11 years; but there are longer periods, so far as I have been able to ascertain, of 26½-27 years, and 104 years. It is probable there are still longer periods. It is these longer periods which prevent us from forecasting what a short period is to produce. This is why, with all that has been written by physical philosophers as to sunspots in India, it is impossible to foretell. This may, perhaps, account for the phrase used by Mr. Danvers, but the real lesson to be learned is one inculcated by himself, that in India, as elsewhere, we shall always be subject to these fluctuations of weather, and therefore we must always be on the look-out and be prepared beforehand. Famines in India are no more due to the English Government than the formation of Goodwin Sands is due to Tenterden steeple. The scanty evidence of the seventeenth and eighteenth centuries is quite sufficient to show a general range of famines. If we want to know what the condition of India was before English rule, we may take into account the corresponding period in the record of Professor Rogers from 1000 to 1750. The accounts in the chronicles of this country are identical with those partial details we have as to India, and with what must have occurred. It was only exceptionally that a Government took any precautions, and that for a reason which is patent enough and yet has not been taken into account. Pestilence and famines are held by priests, in all ages and climes, to be, as described in the beginning of the "Iliad," examples of divine vengeance. The proper remedy is suitable sacrifice of a human being, of an animal, or emblematically. A ruler neglecting this great law, and propounding secular methods, was in danger of being denounced as profane, and the author of the calamity. In our chronicles, as in the Indian, the price of grain is to be found as a safe test of the condition of the country. From time to time there are periods of famine of greater intensity, and these, as Mr. Danvers observes, came together, because they are mostly caused by a long continuance of a change of the atmospheric conditions. Thus, in the middle of the last century, it will be seen from the tables in Adam Smith's "Wealth of Nations" that this country expected grain every second year. There was favourable weather in Europe and favourable crops, and thus the French Revolution was staved off. The horrors of that revolution, and of the wars that accompanied it, were aggravated by the severe cycle of weather at the end of the last century and the beginning of this; 1786 was a severe year, like this. It is totally impossible that the famines in previous centuries can have been milder in India than those of late years, but it is perfectly conceivable that in the great famine the deaths were augmented by the enormous increase of population which has taken place under the protection of English rule, and which will be promoted by the development of railways. This leads to the discussion of the relative merits of railways and hydraulic works of irrigation and navigation. It is a most astonishing thing still to hear that railway expenditure should be abolished in India and appropriated to water enterprises. All these statements rest upon an imagination that India is a country under conditions totally different from all others in this planet, and that it can be treated like as if it were in the moon, without reference to mundane experience. India, with the Ganges and the Indus, has its parallel in North America with the Mississippi and St. Lawrence. The water communication—natural and artificial—in North America differs in this respect from India—that it is much more effective. Nevertheless, in the United States and Canada a full provision of railways has been made, in comparison with which the 15,000 miles of Indian railways are contemptible. So far from the Government of India being entitled to praise, it is exposed to censure, as the Governments of China and India are most backward with regard to railways. The United States Government has expended enormous sums in the Mississippi far beyond what we have in the Ganges, while the Canadian Dominion has been careful for the St. Lawrence. They look after railways and water too. The other countries having old waterways, England, Holland, Belgium, Lombardy, Egypt, Russia, and France, maintain their waterways, but have to rely for carriage mainly on railways. The reason is an economical one. Transport is a great element in the price of an article at a market. Indeed, it may be prohibitory. Water transport on the Mississippi, Ganges, St. Lawrence, and Rhine, is very valuable, but the railway has peculiar qualities, and is found most usefully to supplement it, and in many cases to supersede it. No power of wishing will get over these conditions, and we must go on to supply India with the requisite railways, not forgetting water enterprises, and not allowing an unbusinesslike system of finance and public accounts to keep us from doing in India what every other country in the world has done. With every defect and early mismanagement, North America, England, France, Germany, Belgium, Holland, Russia, and other countries, have not been ruined by providing railways, but have been very greatly benefited. So, too, the reason why so large a proportion of money has been devoted to railways, and so small a proportion to water industry in India, is a simple one, and should be understood. It was the existing produce of all India which had to be provided for and had to be provided for by railway transit; an amount so enormous that the existing railway system is utterly inadequate. Waterways cannot effect what is wanted. Already the benefit of railways is vast; and by help in the improved distribution of food means have been provided for the maintenance of a larger population, and for the better protecting the whole population against the ravages of pestilence and famine. As irrigation and canal works and wells are extended, so they will create a further demand for railway extension. There is no amount of discussion and of pamphlets which can prevent China and India from being provided with railways. The economic operations of the world tend to create economic laws, which the talk of no bazaar in India can control or resist; and the sooner the facts are recognised the better will it be for the welfare of India, and of the empire at large.

Mr. Wm. Digby writes:—Of the paper itself, as a narrative of famines in India, I have nothing to say, except in terms of praise of the concise and interesting manner in which the author has gathered together, from various sources, so large a mass of information. But, the paper seems to me to be wanting, inasmuch as there is not appended to it a summary of the facts, indicating, in pointed manner, the result of the investigations recorded. I have worked out such a summary for myself, and, generally, have analysed the paper. I found, reckoning the last great famines (those of 1876 to 1878) not as one, which Mr. Danvers has done, but as three, viz., the famine in Southern India, the famine in Bombay, and the famine in the North-West Provinces, that during the eighty-five years which have elapsed of this century, Mr. Danvers records twenty-two famines as having occurred in India. In the three previous centuries, *i.e.*, the 16th, 17th, and 18th, there were only the same number of famines, and several of these (probably one-third) were due to wars, and devastation and insecurity accompanying a warlike condition of things. From devastation and insecurity, by our rule, we have preserved India, and yet the appalling fact is stated by an Indian official on unimpeachable evidence, that famine is now four times more frequent than it has been during the 300 years preceding the commencement of the present century—that is prior to the general extension and consolidation of British rule in India. This fact does not in the slightest degree surprise me; it is in accordance with the conclusions which, sometime ago, I worked out for myself. To my mind the fact is of so terrible a character, and involves consequences of so frightful a kind, that I much regret Mr. Danvers, with all the wealth of information in the India-office available to him, has not carried his investigations further, and has not drawn the inevitable conclusions which his paper supplies. At the least I hold he should have endeavoured to explain how and why such a condition of things exists as this—that in the period of most extended British rule and improved means of railway and other communication some of the most frightful famines known to history have occurred. The following Table drawn from the authority to which Mr. Danvers owes many of his most interesting statements is of serious omen:—

Period.	Number of Famines.	Mortality.
1800 to 1810	3	—
1811 to 1820	3	—
1821 to 1830	3	—
1831 to 1840	3	—
1841 to 1850	0	—
1851 to 1860	0	—
1861 to 1870	6	4,585,000
1871 to 1880	6	6,736,420

The last two decades were pre-eminently years of the railway era. In certain districts traversed by railways the mortality in 1877 and 1878 was $22\frac{4}{5}$ths per cent., in districts not traversed by railways only $20\frac{4}{5}$ths per cent. To my mind the frequency of famines now occurring in India is due entirely to the system of rule existing in that country. This is, to me as an Englishman, a most sorrowful conclusion. That we, the English rulers of India, without ever intending anything of the kind—indeed, on the contrary, desiring to do that which we hoped would be the best for the people of India—are responsible for an amount and an intensity of suffering unparalleled during the present century in any part of the world, is most distressful, and creates in my mind feelings of the most painful character. Had I been present at the meeting I should have endeavoured — by producing chapter and verse from India-office records—to prove the truth of my contentions. To do this, however, with anything like adequacy would have taken up far more time than, under the conditions upon which papers are read and discussions follow at the Society of Arts, the chairman could possibly have allowed to me. Furthermore, a consideration of the matters I should have urged would have led me to speak in terms of strong indignation respecting a system of rule which could possibly be attended with such consequences. Probably the expression of the feelings engendered in my heart by a study of this question would have carried me beyond the decorum of your gatherings.

TWELFTH ORDINARY MEETING.

Wednesday, February 24, 1886; Professor F. Guthrie, F.R.S., in the chair.

The following candidates were proposed for election as members of the Society:—

Adderley, Augustus J., C.M.G., Davenport, Bridgnorth.

Doxford, William Theodore, Grindon-hall, Sunderland.

Lydall, William Hawthorne, 60A, Watling-street, E.C.

Parry, Sydney Gambier, 3, Clareville-grove, South Kensington, S.W.

Steel, Robert Elliot, M.A, Spring Cliffe-house, Heaton-road, Bradford.

Thorpe, Thomas Wells, Albion Brewery, Whitechapel, F.

The following candidates were balloted for and duly elected members of the Society:—

Beadle, Charles, Belvedere, Kent.
Wheen, Francis, 21, Norfolk-square, W.
White, John Samuel, Clarence-house, East Cowes-park, Isle of Wight.

The paper read was—

THE EMPLOYMENT OF AUTOGRAPHIC RECORDS IN TESTING MATERIALS.

By W. C. Unwin, M.Inst. C.E.

In the ordinary use of materials of construction, which are deformed by the loads to which they are subjected, there is a very simple relation between the stress and the deformation. According to Hooke's law, the stress and the strain are proportional. For instance, if a bar is subjected to a longitudinal pull, and if p is the tension per unit of area, and λ the extension per unit of length,

$$p = E \lambda$$

where E is a modulus or coefficient of elasticity for the material of the bar, a material for which this law is exactly satisfied is called a perfectly elastic material.

Now, materials like cast-iron and cast-brass are never in their initial condition perfectly elastic, but they are very nearly perfectly elastic for moderate stresses. Materials which have been rolled or hammered are generally almost perfectly elastic up to some limit of stress, which we call the elastic limit for the material, but beyond that limit the elongations increase enormously. For an ordinary mild steel bar the elongations up to the elastic limit may be 1-500th of an inch in 10 inches. With half a ton more load the extension may be 4-10ths in 10 inches, or 200 times as much.

The deformations which occur within the elastic limit are almost entirely temporary. If the load is removed, the deformation vanishes. We infer naturally that the bar is not injured by the load. On the other hand, if the load exceeds the elastic limit, the deformation is chiefly permanent. The bar does not recover its original condition when the load is removed. The bar has certainly been altered; whether it has been injured requires further investigation.

Up to some limit of stress not at present very definitely known, a bar becomes more perfectly elastic by the imposition of a load. If ten tons is the elastic limit of a bar, then a load of twelve tons will permanently stretch it, but afterwards it will be almost perfectly elastic up to twelve tons. The elastic limit will have been raised, at least for stress of the same kind. It would seem, therefore, at first sight, that we could improve the materials of construction by loading them. We can certainly raise very much the elastic limit above its primitive value. Having raised the elastic limit, we might adopt higher working stresses with the assurance that they would not produce permanent deformations of our structures.

But it is easy to see that such an artificial raising of the elastic limit is not practicable in large structures. An ordinary boiler plate three feet wide and half-inch thick would require a load of 360 tons to raise its elastic limit to 20 tons. It is not convenient even if it be possible to apply such a force. And hence the boiler-plate must, practically speaking, go into the boiler with whatever elastic limit it happens to have been endowed when it left the rolls. It is for this reason that the primitive elastic limit of a material is an important point to observe in testing, at all events in testing such materials as wrought-iron and steel, because practically it fixes the greatest allowable working stress.

For let us see what would happen if we loaded a structure built of mild steel plates beyond the elastic limit. Suppose we have to build a 100 feet span bridge. With the ordinary proportions of such a bridge, with stresses of about 5 tons to the square inch, for instance, it takes a deflection as the load passes over it of about an inch, and recovers itself when the load goes off. Suppose we doubled the ordinary load; the deflection would still be only about 2 inches in the 100 feet span. But with a little more than double the ordinary load, the bridge would be loaded beyond the primitive elastic limit of the plates, and then the bridge would suddenly deflect something like 20 feet. I do not know that it would be less strong to resist future loads than before, but a deflection of 20 feet would be awkward for the trains.

Of course this is putting the case a little crudely. To be exact, the bridge must be supposed so exactly designed that all parts are equally stressed. But still it puts broadly the case that in actual large structures we have to deal with the primitive elastic limit, and that if the working stresses exceed that limit, there will be relatively enormous deformations. We shall see presently that autographic diagrams mark for us the elastic limit of a material very conveniently.

There are other materials which are altered in shape by very small forces. The clay moulded by the potter shapes itself to the slightest touch. We call such materials plastic materials, and the arts concerned with the use of them the plastic arts.

Iron and steel, and some other materials, become plastic at high temperature, and all the operations of rolling and forging take advantage of that property. But it is due to the experiments of a very distinguished Frenchman, M. Tresca, that we know that iron and steel, and many other materials which are elastic under ordinary conditions, are plastic under sufficiently severe stresses, even when cold.

If lead is placed in a cylinder with a hole in it, and pressure applied by a plunger, the lead will flow out like water, if the pressure is sufficiently intense. The pressure at which this kind of flow is produced, M. Tresca calls the pressure of fluidity. Under this pressure, and without any increase of pressure, the lead will continue to flow. In other words, the amount of deformation is unlimited; the deformation goes on without increase of stress.

I believe it was Prof. Cotterill who first pointed out that in the crushing of iron and steel cylinders in ordinary testing, the pressure of fluidity is reached. As the cylinder crushes down, in this case, it enlarges in diameter, consequently the load must be increased to continue the deformation. But Prof. Cotterill showed that the stress per square inch of the cylinder was nearly constant. While the load increased from 16·7 to 41 tons, and the cylinder crushed down from 0·62 to ·50 inches in height, the stress only increased from 38 to 51 tons. Table I. shows the results of an experiment on a lead cylinder by Prof. Kick.

TABLE I.

Load in tons.	Height in mm.	Stress per sq. in. in tons.	
0	64·4	0	The stress is calculated on the middle section of the distorted cylinder.
2·9	57·8	·82	
3·25	47·6	·74	
3·35	42·9	·69	
3·45	40·9	·67	
3·95	34·4	·64	
5·65	28·2	·74	

The relation between the stress and deformation in such a case as this is not difficult to obtain. For when the deformation is so large, we may neglect any small change of density in the material. Hence if P_1 is the load on the specimen when the length is l_1 and area ω_1, and P_2 the load when the length is l_2 and area ω_2,

$$\frac{P_1}{\omega_1} = \frac{P_2}{\omega_2} = p,$$

the pressure of fluidity. And, since the density is constant,

$$\omega_1 \, l_1 = \omega_2 \, l_2.$$

Hence

$$P_1 = P_2 \frac{l_2}{l_1};$$

or if l is the length with the load P, which produces plastic yielding, and $l + \lambda$ the length with another load P_1,

$$P_1 = P \frac{l}{l + \lambda}.$$

Intermediate between bodies which are perfectly elastic or perfectly plastic are bodies which extend or compress at an increasing rate as the load increases, but which gain rigidity in the process, so that they do not go on indefinitely yielding with any given load, and recover part of the deformation if the load is removed. Thus the following Table shows the behaviour of india-rubber:—

TABLE II.

	Load. kil. per cubic cm.	Relative elongation or contraction.	Stress per square inch.
Compression	—3	—·185	2·4
	—2	—·159	1'7
	—1	—·076	0·9
	0	0	0·0
Tension	1	·121	1·12
	2	·316	2·6
	3	·548	4·6
	4	·859	·75
	5	1·309	11·6
	6	1·794	16 7

The law for these bodies is not known. But approximately $p = E \frac{\lambda}{1 \pm \lambda}$ according as the stress is tensile or compressive.

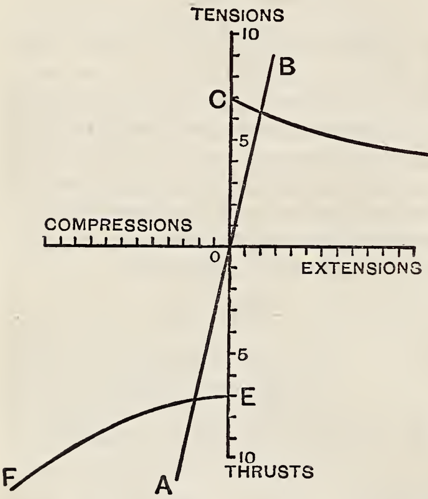
Further, bodies of this kind do not generally take their whole elongation when the load is first put on. They go on elongating for some time with a given load. But the increase of elongation is not indefinite; it reaches a limit, and stops.

GRAPHIC REPRESENTATION OF THE RELATION OF STRESS AND STRAIN IN A BAR.

Suppose a bar placed in a testing machine and subjected to a stress increased regularly till the bar breaks. For every value of the stress there will be a corresponding value of the strain or deformation. We may plot the strains as abcissæ, and the stresses as ordinates, and obtain a curve which may be called a stress and strain diagram for the bar.

Now, for a perfectly elastic bar the stresses are proportional to the strains, and the stress and strain diagram is a straight line:—

FIG. 1.

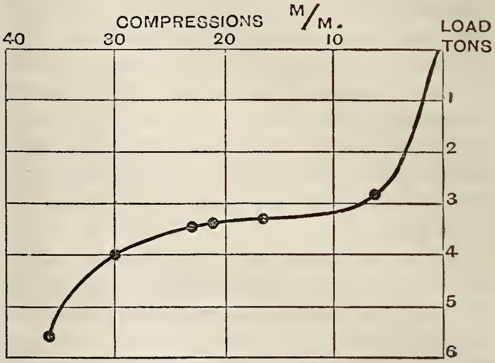


We may set off compressions to the left, extensions to the right, tensions upwards, and thrusts downwards. Then a single straight line through the origin would give the relation of stress and strain both for compression and tension in a perfect elastic material.

For a plastic material the stress and strain diagram would be quite different. The load on the bar would have to reach some limit, P, before the pressure of fluidity was reached. In a bar in compression the bar would thicken laterally by compression, and the load would have to increase to continue the compression. In a bar in tension the bar would contract, and the load would have to diminish in order that the stress might not exceed the resistance. Hence, curves for a plastic material would be such as C D or E F.

Figure 2 shows a plotting of Professor Kick's experiment on a lead cylinder. The lead was almost perfectly plastic in the later part of the experiment, and the plastic part of the curve is very well shown.

FIG. 2.



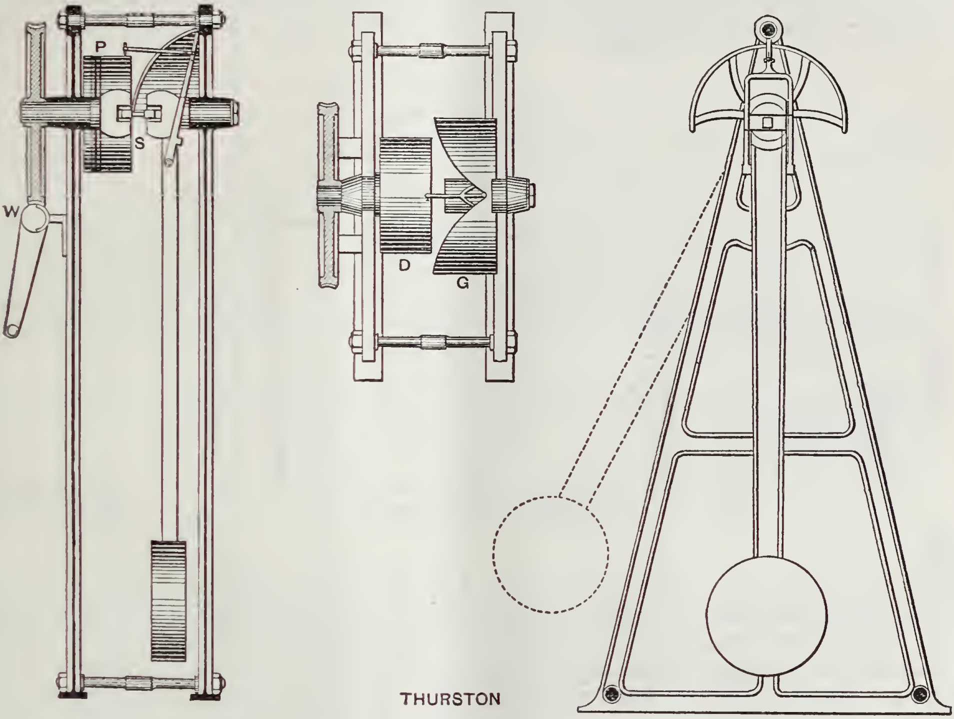
AUTOGRAPHIC DIAGRAMS.

It can now be seen that if a testing machine could be made itself to draw an autographic diagram of this kind—a stress-strain diagram —we should have a very interesting record of the quality of the bar. Not only would such a diagram show the elastic limit, if there was one, and the breaking load, but it would show completely the mode of variation of the extension with the stress, and enable us to draw conclusions as to the amount of elasticity and amount of plasticity of the material. An autographic record of this kind has other advantages. From sufficiently detailed measurements during the test, we could plot the diagram afterwards. There are some hundreds of such plotted diagrams in the Report of the United States Testing Board. But this is laborious, and it is very convenient to have it done mechanically. Further, the autographic diagram is a trustworthy record—free from personal bias, and free from accidental errors of record. Mr. Wicksteed, indeed, thinks that it is so trustworthy that an autographic diagram taken in the absence of the inspector of materials might be relied on as if the inspector had been present. That is, however, claiming far too much for autographic apparatus, for it is easy to see that a diagram can be tampered with. The datum line is easily displaced if we want to increase the loads, and a finger on the pencil will increase the extension recorded. Still, without putting the autographic apparatus in the place of an inspector, as a check on the manufacturer, it may be conceded that a per fectly continuous autographic record of a test, showing everything that has happened to a bar, is extremely useful.

THURSTON'S AUTOGRAPHIC TESTING MACHINE.

Mr. Thurston was the first to use a testing machine which drew autographically a stress and strain diagram. The machine was a small torsion machine (Fig. 3.) capable of twisting short specimens of about half an inch in diameter. The specimen, S, is held in two jaws, one of which is connected with a worm and wheel, W, by which the twisting moment is produced; the other is connected with a heavy pendulum, the angular movement of which bears a definite relation to the twisting moment. To get an autographic record, Professor Thurston made this ingenious arrangement. The clip at the worm wheel end of the specimen carries a drum, D, on which is a sheet of section paper. To the arm of the pendulum is attached a light lever, carrying a pencil, P, which marks the paper. As the drum turns through the same angle as one clip, and the pencil the same angle as the other clip, the difference of these angles is the twist of the specimen; and the pencil will draw a circumferential line on the paper, the length of which is proportional to the amount of twist of the specimen. To get a stress and strain diagram, however, the pencil must have another movement at right angles proportional to the twisting moment. To get this there is a fixed guide curve, G, on the frame of the machine. The pencil moves relatively to this fixed curve through the same angle as the pendulum, which balances the twisting moment. The guide curve is of such a form that it forces the pencil to move parallel to the axis of the drum a distance proportional to the twisting moment for every position of the pendulum.

Fig. 3.



Hence, the pencil draws a curve on the paper the abscissæ of which are the strains, and the ordinates the twisting moments. Fig. 4 (p. 340) shows one of these curves. The use of the machine, says Professor Thurston, is to compel the metal to tell its own story, and to give a permanent record and graphical representation of its strength, elasticity, and every other quality brought into play during its test, and thus to exhibit all its peculiarities.

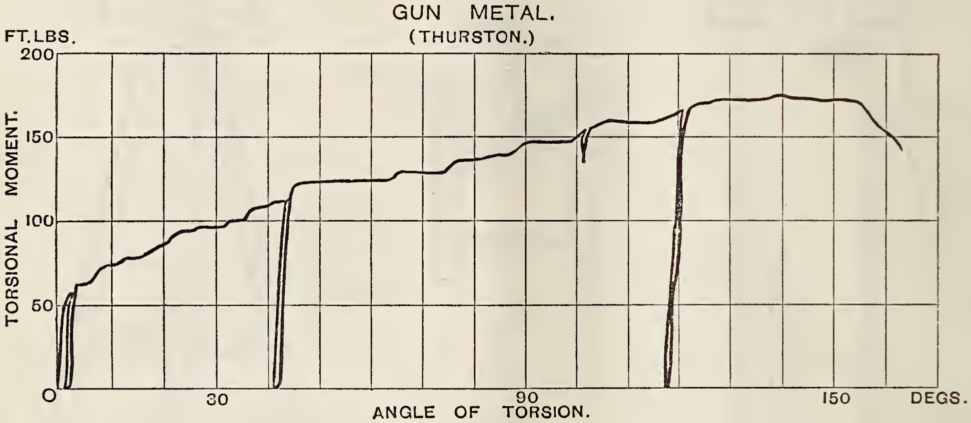
Now Professor Thurston's machine is undoubtedly very ingenious, and though very small, it at once enabled its designer to detect the peculiarity in the behaviour of certain materials, that when a load is applied to a specimen, taken off, and reapplied, the elastic limit is found to have been raised. The material is elastic not only up to the stress previously applied, but it is elastic up to a stress a little beyond the stress previously applied. Probably we must use the term elastic limit a little loosely in stating this, but that there is a marked effect of this kind will be shown presently.

Professor Thurston's machine, besides its smallness, has some defects. It is not usual, or generally convenient, to use a torsion test, and it is a defect of principle that the instrument takes its movements from the clips which hold the specimen, and not from the specimen itself. Any crushing of the ends of the specimen gets registered as twist, which is inaccurate. There are irregularities in Prof. Thurston's diagrams which look like irregularities of record.

Professor Ewing's Apparatus.

Amongst the earliest attempts to take autographic diagrams, I should mention those of Professor Ewing. While Professor of Engineering in Japan, Professor Ewing made some experiments, in 1880 on the tension of wires.* The wire suspended in a strong frame carried a tank capable of holding 100 kilos. of water. By running water into the tank the stress on the wire could be increased, and by running it out the stress could be diminished. The load was proportional to the height of the water in the tank, the weight of the tank being independently balanced. A float in the tank drew a sheet of paper transversely to the wire distances proportional to the load, and a pencil attached to the wire moved distances proportional to the elongation. With this comparatively rude and small apparatus Professor Ewing obtained some very interesting diagrams.

Fig. 4.



With annealed iron wire, and with a regular admission of water, that is a constant rate of increase of load, the diagram was of a form showing a well marked elastic line, followed by a curve becoming nearly horizontal. This corresponds to a partially plastic stage.

Now, suppose that while drawing this line the flow into the tank was stopped, and the load left on the bar for forty-five hours, and then again the load regularly increased. A very singular kink is produced in the curve. While the load remains steady, the elongation slowly increases, and the pencil draws a horizontal line. But during the time the load is steady the bar gains rigidity, so that for a more or less considerable increase of load very little further elongation occurs, and the pencil then draws a nearly vertical line, strictly, an elastic line. At some increase of load, the new elastic limit is passed, and the line again tends to become horizontal, showing a rapid increase of elongation.

Professor Ewing next tried the effect of removing and replacing the load (Fig. 5). As the load is removed the pencil draws a straight nearly vertical line, showing that nearly all the elongation is permanent. On replacing the load the pencil retraverses this line, as might be expected. But what is very singular is that this straight elastic line now extends not only above the old elastic limit, not only up to the previous load, but to a point higher than either of these. I am inclined to attribute this rise of the elastic limit above the greatest previous stress to vibrations during the unloading and reloading. But it is certainly a curious phenomenon.

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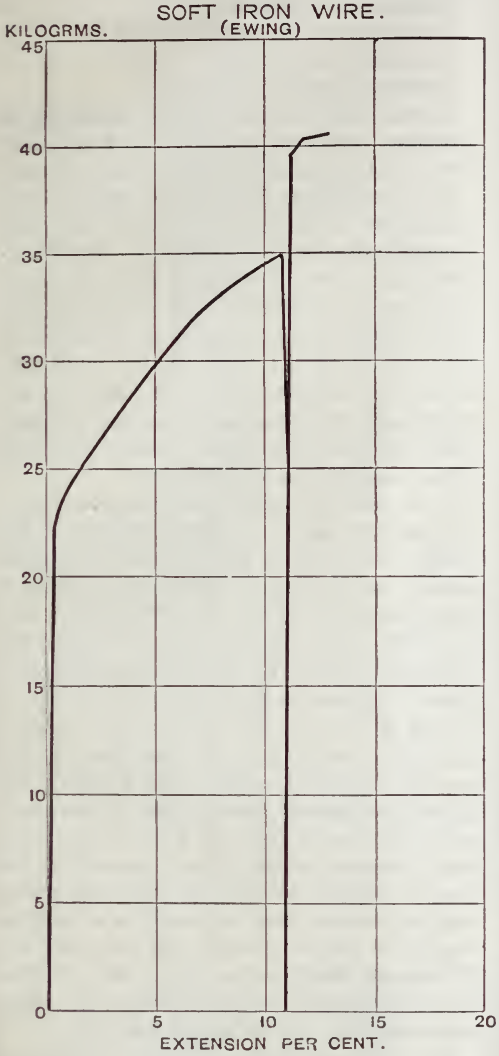
* Proc. Royal Soc., 1880.

Fig. 5.



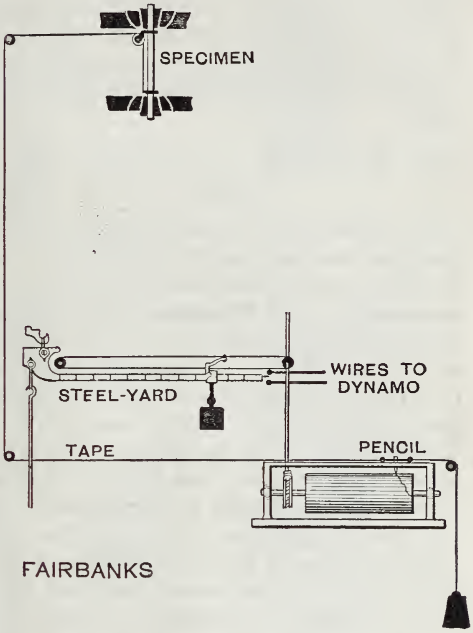
The Polmeyer Autographic Apparatus.

In 1882, I saw at Dortmund a 50-ton testing machine, designed by Professor Polmeyer, expressly for autographic testing. It is a pendulum machine with a very long pendulum, having a ton weight at the end. As one end of the specimen is pulled by an hydraulic press, the other pulls on the pendulum, and the stress is related to the angular rise of the pendulum. It is easy to see that a paper connected by one wire to the pendulum, and a pencil connected by another wire to the specimen, can be so arranged as to draw a true autographic diagram.

Fairbank's Autographic Apparatus.

In Mr. Abbott's little treatise on testing machines there is described in considerable detail a large testing machine, constructed by Messrs. Fairbanks, in America, with an autographic apparatus attached. The machine is a 100-ton machine, and adapted for tension, compression, bending, and other tests. It is strictly a very large platform weighing machine. One end of the specimen is connected with the platform, the other end carried in a crosshead, by the movement of which the stress in the specimen is produced. As the stress is produced it is weighed by the steel-yard connected with the platform.

Fig. 6.



Now to effect the adjustment of counterpoise on the steel-yard to the stress on the specimen, a very ingenous electrical arrangement is used As the steel-yard rises or falls against its stops it completes an electric circuit, which starts an electro-magnetic engine, which moves the poise. Thus, if the lever rises, showing that the stress exceeds the load applied by the steel-yard, the electro-magnetic engine moves outwards the counterpoise till, balance being restored, the circuit is broken. Geared to the arrangements for moving the counterpoise is a drum or cylinder on which the record is made, and the rotation of this drum is therefore exactly proportional to the movement of the counterpoise on the steel-yard. Consequently, a pencil held fixed over the drum would trace a line the length of which is proportional to the load on the specimen.

The pencil, however, has a second motion parallel to the axis of the cylinder, derived from a thin flexible steel tape attached to two clips on the specimen. This is led off over pullies, so as to pull the pencil exactly along the cylinder. The defect of the arrangement is that the elongation is not magnified, and the tape is so long that it is hardly possible it can give the pencil a quite true movement free from any error due to slack in the tape. It is stated, however, that the error does not exceed $\frac{1}{100}$th inch.

MR. WICKSTEED'S AUTOGRAPHIC APPARATUS.

Mr. Wicksteed's apparatus (Fig. 7.*) differs from any other autographic apparatus in this, that it is absolutely independent of the lever and poise weight. Mr. Wicksteed gets the motion of the pencil proportional to the load, precisely as in the ordinary steam-engine indicator. One end of the specimen is held by the ram of the hydraulic press, F, which is used to take up the elongation of the specimen, and keep the lever floating. Apart from friction, the pressure in the ram cylinder is proportional to the load on the specimen. A pipe from the hydraulic press is led to a cylinder with a piston about 1 inch area, controlled by a somewhat powerful spring, 15 inches long when unloaded, and 5 inches long when loaded with 22 cwt., the full load which comes on the small piston, with 50 tons on the specimen. As the load on the specimen increases, the spring is compressed, and moves horizontally a distance proportional to the load. Simultaneously with this, a wire virtually attached to one clip on the specimen, S, and passing over a pulley on another eight or ten inches distant, pulls round the indicator barrel a distance proportional to the extension. Hence the pencil traces on the paper a stress and strain diagram.

Now, there is no doubt a considerable practical convenience in taking the load record from the hydraulic press, for it is then quite independent of the manipulation of the lever. Whatever stress is put on the specimen is shown in some way on the diagram. But a very obvious objection to the method is that the pressure in the hydraulic cylinder is not, in fact, at all exactly equal to the load on the specimen. Putting aside other forces, the pressure in the hydraulic press consists of these parts :—

Tension of specimen.
Unbalanced part of counterweight.
Friction of cup leather.
Friction of guides of shackles.
Inertia of the mass of parts consisting of shackles, counterweight, ram, and adjusting screws, if there is any change of speed of ram.

The most important of these are the frictional resistances to the movement of the ram, and especially the cup leather friction. Mr. Wicksteed states that this friction does not exceed 16 per cent. of the whole load on the ram, and that so long as the ram is kept moving, it is proportional to the load on the specimen. Hence, if the diagram be marked at two points, say at one ton and with the maximum load, the lever being then floating, the scale of the diagram can be determined.

I am bound to admit that I thought originally that the want of proportionality of the friction to the load would prove a greater obstacle to getting accurate diagrams than it has actually proved. Mr. Wicksteed has shown that he can take diagrams in which the scale of loads is, for all practical purposes, exact. By some adjustments of the counter weight of the ram and of the initial tension, the scale of equal parts is exact from one ton up to the breaking weight. But I think it is a difficulty with this apparatus that these adjustments are necessary, and I have still some doubt whether greater wear in one part of the ram, or deposit on the ram from the water, may not destroy that accuracy in a sensible degree in course of time. At any rate, Mr. Wicksteed would admit that the diagram would not remain accurate unless the main ram were kept moving in one direction.

Mr. Wicksteed takes diagrams sometimes in this way. He runs the jockey weight out to the end of the lever so that it never floats during the test. He then pumps water into the ram cylinder till the specimens breaks. He thinks that as the ram is continually moving forward, the friction of the ram is as constant as possible, and so produces no irregularities in the scale of the diagram. Further, as the movement of the ram is at uniform speed, no effects of inertia can be produced. To a great extent, no doubt this is so. But it is to be noted that the mass

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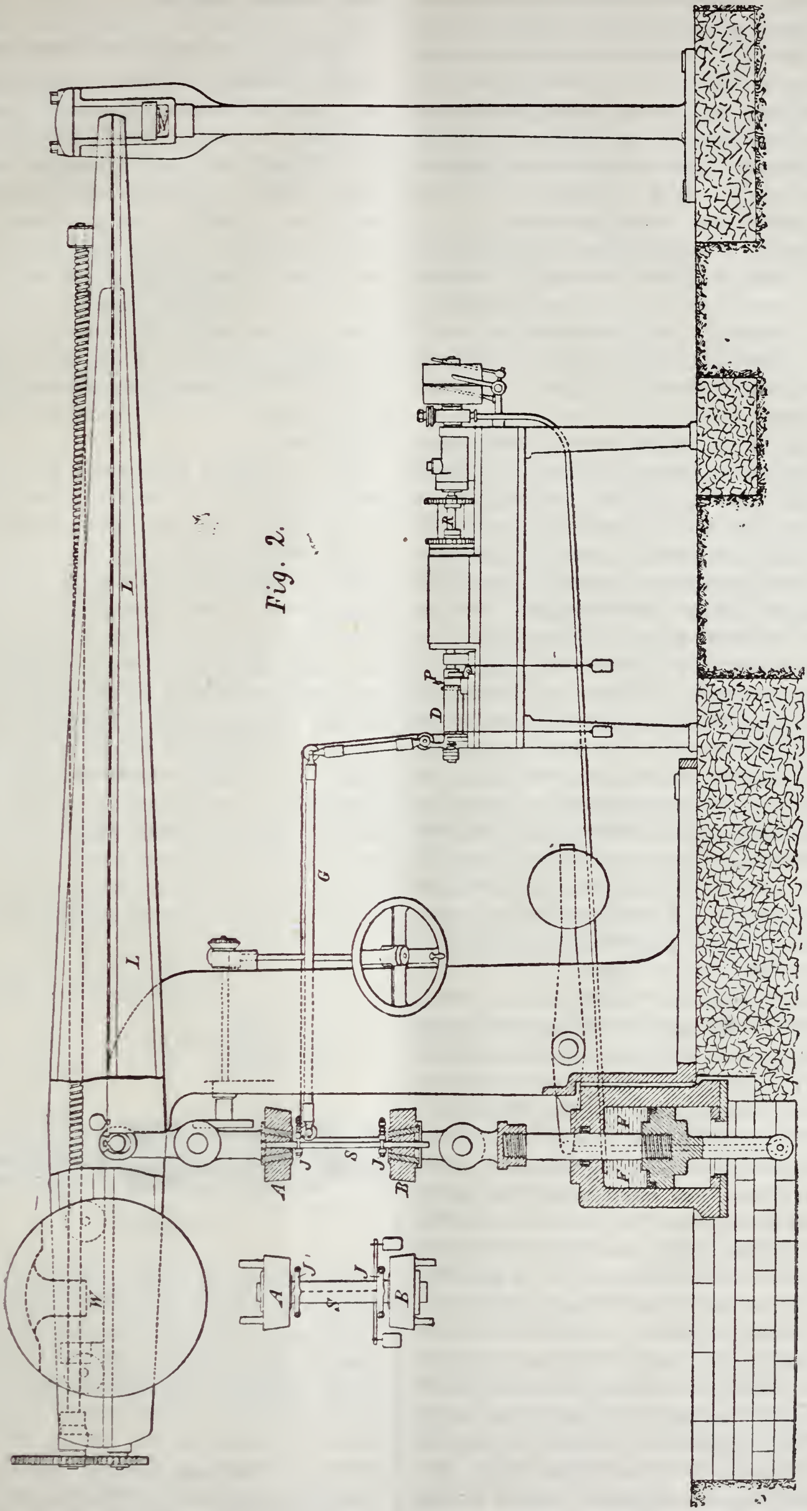
* This figure has been kindly lent by the Editor of *Engineering*.

FIG. 7.

Fig. 2.



AUTOGRAPHIC TEST RECORDER.

attached to the ram is very considerable—two tons or more. Then the whole system of water column, press cylinder, links, and so on, is elastic. So that if sudden changes occur, as I think they do occur, in the resistance of the specimen, these may set up oscillations of the elastic system between the specimen and the recording pencil. I have seen no autographic apparatus yet in which the effect of inertia appeared to me to be quite eliminated.

I now come to speak of two arrangements which Mr. Wicksteed has introduced, without which I do not think his apparatus would have proved successful. The friction of the small indicator piston is really much more serious than that of the main ram. For, if it is a much smaller force, it also must be overcome by pressure on a much smaller area, and hence it would produce a greater effect on the motion of the pencil than the friction of the main ram. More than this, the indicator piston is not always moving in one direction; so that the friction would sometimes increase, sometimes decrease, the height of the diagram. To get rid of the friction of the indicator piston as much as possible, Mr. Wicksteed keeps it in continuous rotation, and that the friction is not at all inconsiderable may be judged from this, that he estimates that it takes one horse-power to keep this little piston revolving. It is well known that the coefficient of friction at a tolerably high speed is very small, and it is to this diminution of the coefficient of friction, and to the condition of vibration in which the piston is kept, that I attribute the very great sensitiveness of the pencil to the changes of pressure in the main cylinder.

The next ingenious arrangement is this, Mr. Wicksteed's machine being somewhat large, and it being necessary to take a belt to it, it is convenient to place it some distance from the specimen. Then the wire which gives the motion to the barrel proportional to the extension would be liable to give false motion, partly on account of slack in the wire, partly because of movement of the specimen relatively to the fixed autographic machine. By leading the wire over two radius bars, G, a perfectly exact motion of the indicator barrel is obtained.

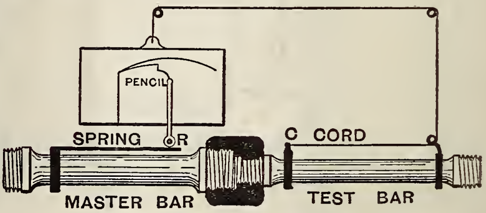
The greatest objection to Mr. Wicksteed's plan of taking the load indication from the hydraulic cylinder is that it necessarily leads to making the autographic apparatus large, heavy, and expensive. Merely to draw a pencil line two or three inches long, Mr. Wicksteed has an apparatus which weighs nearly a ton. It will be seen presently that much simpler apparatus can be used, if we adopt another principle.

Professor Kennedy's Machine.

Prof. Kennedy has constructed a machine on a quite different and extremely interesting principle. In some forms of testing machine it is difficult to get a motion from the weights which load the lever. It is easy in machines in which a single jockey weight moves along the lever or steel yard, but difficult if part of the load is due to weights hung at the end of the lever. Besides this, if the indication of the stress is taken either from the lever or the hydraulic press, some effects of inertia of these heavy parts affect the diagram, if the resistance of the specimen changes at all suddenly.

Now a straight well-turned bar which has been subjected to a load is a very perfectly elastic spring. Its elongations are practically exactly proportional to any less load. Hence, Professor Kennedy has thought of taking the elongations of such a prepared bar to give the motion to the pencil which is proportional to the load. The test bar and the master bar are connected and placed in the testing machine so that they are both subjected to the same stress. Near them is placed a smoked glass plate, which has a horizontal motion proportional to the elongation of the test bar. Simultaneously, a point moves on the glass plate in an arc of a circle, its motion being proportional to the elongation of the master bar, and, therefore, to the stress in the test bar.

Fig. 8.



KENNEDY

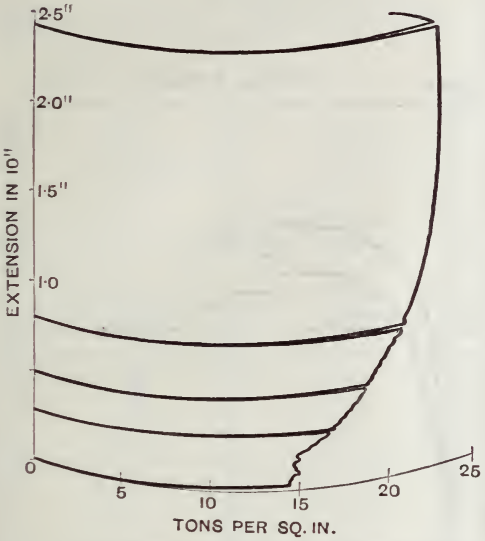
The elongations of the master bar, being all within the elastic limit, are extremely small. They must be greatly magnified by mechanical means to give adequate motion to the tracing point. Professor Kennedy, I believe, magnifies the extensions of the master bar about 200 times, and those of the test bar about twice, getting a diagram, roughly speaking, about three inches square for ordinary test bars.

The mode of getting the magnification of the elongation of the master bar is perfect in principle. Without explaining exactly Prof. Kennedy's arrangement, the method can be explained very simply by the rough diagram Fig. 8. Suppose a small roller, having its centre fixed relatively to one point on the bar, is turned by frictional contact with a finger fixed relatively to another point of the bar ten or twelve inches distant. The circumference of the roller will turn through a distance equal to the elongation of the ten or twelve inches of the master bar. Now if the roller is small, and carries a long light radius bar, at the end of which the tracing point is fixed, the elongation will be magnified without any lost time.

Fig. 9.

IRON BAR

(KENNEDY)



It is a small but not serious objection that the load ordinates are circular instead of straight in Professor Kennedy's diagram. The great merit of the machine is the very perfect registration of the stress free from errors due to any action of the machine. It is rather a delicate instrument for scientific research than an instrument for daily use, and if Professor Kennedy gets rid of difficulties in one direction, the larger mechanical magnification he is obliged to adopt introduces difficulties of another kind.

The Author's Apparatus.

In 1882, when selecting a testing machine for Cooper's-hill College, the author perceived that Mr. Wicksteed's type of testing machine lent itself very conveniently to the application of autographic apparatus, and of autographic apparatus of a simple kind, which would not interfere with any of the ordinary operations of testing. One apparatus on a rather large scale was constructed, and afterwards a more compact one, which is on the table. The chief merit of the apparatus is its extreme simplicity, but at the same time it is quite accurate in principle, and gives as perfect a record as is possible in a small diagram three or four inches square.

In the Wicksteed type of testing machine the stress is weighed by a steelyard, on which there is a travelling jockey weight weighing one ton. This is driven by a large screw, consequently the rotations of the screw are exactly proportional to the movement of the weight, and to the stress on the specimen. It is from this screw that a vertical paper cylinder is driven. A small catgut belt drives a worm, acting on a worm wheel of 200 teeth on the paper cylinder. As the resistance of the paper cylinder is very small, the motion given by the belt is quite accurate, and it has this convenience, that by means of a stepped pulley several scales are available for the diagram. Necessarily, the specimens vary in size and strength, and it is extremely convenient to enlarge the load scale of the diagram for small specimens, and diminish it for large ones. The pencil slides on guides parallel to the axis of the paper, and it is connected to the specimen by a very fine wire, kept strained by a counter weight. The wire is so fine that a counter weight of two or three ounces is quite sufficient to keep the wire taut, and overcome the friction of the slides.

On the specimen are two clips, the construction of which is so arranged that they are perfectly rigid in position on the bar, and which define exactly the length in which the elongation is taken, and do not become slack as the bar contracts. It is extremely convenient to magnify, more or less, the elongation, so as to get a larger diagram. The author has tried several plans. That most generally convenient is very simple. The thin wire is attached to the top clip, taken over a pulley on the bottom clip, again over a pulley on the top clip, and then horizontally to the guide pulley on the autographic apparatus. In this way the extension is exactly doubled.

At first it was feared that movements of the specimen would affect the record of extension, and the author adopted a plan of taking tw wires from the specimen, one neutralising any error in the motion of the other. He has since found that, by properly placing the apparatus, and leading off the wire from the specimen parallel to the knife-edge of the testing machine, no measurable error is introduced due to motions of the specimen.

Parallel to the knife-edge the specimen has no motion. It has a small vertical motion, due to variation of position of lever, slipping in clips, &c. But the greatest possible motion of this kind would not introduce an error in the diagram of 1-100th inch.

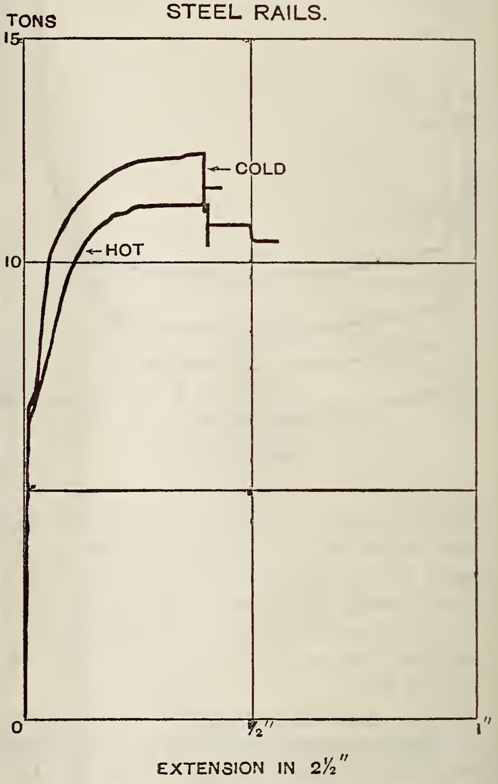
ELECTRIC SEMI-AUTOMATIC AUTOGRAPHIC APPARATUS.

All the ordinary forms of autographic apparatus fail to register in any useful way the small strains which occur within the elastic limit. The strains are, it is true, indicated on the diagram, but on a scale too small to be measured accurately enough for practical purposes. It would at first seem easy to overcome this difficulty by mechanical magnification of the extensions. I have tried a lever arrangement increasing the extensions five times, but a much greater magnification than this is required for the strains within the elastic limit, and with increase of magnification the difficulty and the liability to error rapidly increase. Hence I have been driven to adopt a totally different method, which may in some cases be useful in facilitating the registration of the small strains. A large paper cylinder is connected with the jockey weight, so as to turn accurately a circumferential distance proportional to the load on the specimen. A pencil moves along a slide parallel to the axis. To give motion to the pencil there is an electro-magnet and ratchet-wheel, so arranged that, on sending a current, the pencil moves one step along the slide.

If now a scratch on the test bar is observed through a micrometer, the moment when each extension of 1-1000 inch, or, if necessary, of 1-10000 inch, can be observed—if, then, from each such extension a current is sent by the observer, the pencil will mark a step on the paper cylinder. For the paper cylinder is turning proportionately to the increase of stress. Hence we get on the paper cylinder a stepped figure, the angles of which are points on the stress and strain curve. The use of such an arrangement is that a series of readings are taken and registered rapidly, without needing to stop and read the load, and write down the results.

I have now only to point out some of the peculiarities of diagrams which have been taken. A cast-iron bar gives a smooth curve, nearly straight for some distance from the origin, but curving gradually away, the bar breaking before any considerable plasticity is developed. It is the type of a brittle material. Brass also gives a curve, but much flatter than that of cast-iron in the later part. With brass, the general contraction of the bar is prolonged up to fracture, and there is often no marked local contraction. Wrought-iron, an almost straight line up to the elastic limit; then the line curves slightly, and at a point a little beyond the elastic limit there is often a more or less well marked breaking down point; that is, the material yields plastically without increase of stress. Then the curve follows a law somewhat similar to that of India-rubber, the extensions being very large and mostly permanent. Finally the load has to be reduced as the rate of local contraction be-

FIG. 10.



comes more rapid than the increase of cohesion.

Steel gives a curve similar to that of wrought iron. When the steel is hard there is no marked breaking down point. With soft steel the breaking down point is generally extremely well marked, the elongation during a very small increase of load being sometimes 200 times the whole extension.

FIG. 11.

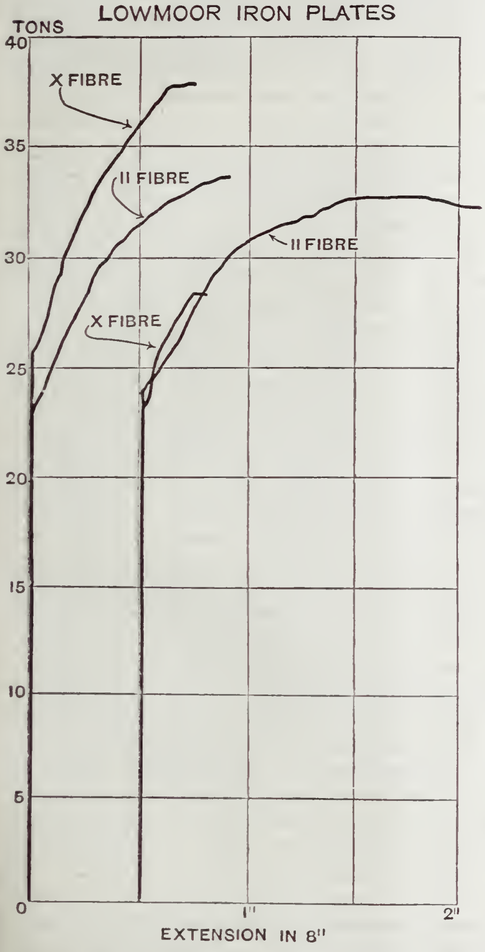
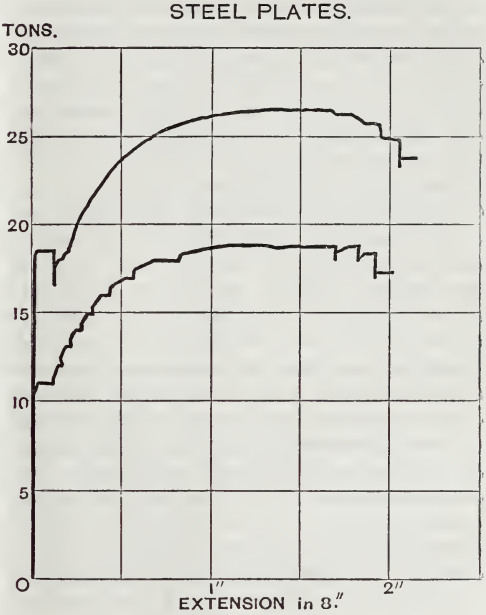


Fig. 10 shows an attempt made to explain the breaking down point. Through Mr. Halpin's kindness I obtained some pieces from the ends of rails rolled 150 feet long. My idea was that the end last passing through the rolls must be colder, and therefore would give a different breaking point from the other end. The steel is so hard, however, that the breaking down point is not well marked; but the diagram shows that the two ends of the rail are different in quality.

Fig. 11 shows the curves for pieces of Lowmoor iron, strained in the direction of rolling, and across it. The difference of character of the bars is distinctly indicated.

Fig. 12 shows the effect of pauses during the imperfectly plastic stage of the extension. The bar pulls out during the three minute pause, and the part of the curve next following is almost vertical.

FIG. 12.



DISCUSSION.

Professor HEARSON said he had listened with much pleasure to the complete account of the testing of materials, and of the autographic record of stress and strain, and could not but congratulate those who were new to the subject on having had the subject so thoroughly explained. Having charge of the testing machine at Cooper's-hill, he had endeavoured to get autographic re cords from it in the following manner. In the instruments described, the elongation had been magnified but little, if at all, and the record was very incomplete, and of little value until the metal became approximately in the plastic condition;

but it was in the early part of the extension, while the material was more or less completely elastic, that it was behaving as it was intended to behave in actual use, and it was its behaviour then of which complete knowledge was most desirable. He thought therefore, that the extensions ought to be magnified many times in that part of the experiment; but if that were done, and the same thing were continued when the material was drawing out, in the plastic condition it would require a very elongated diagram. It therefore occurred to him that the magnification might be effected many times up to a certain point, and then the scale might be changed, and the record completed with but little magnification, or none at all. For that purpose he had devised an instrument of which he drew a rough sketch on the board. There was a lever resting on a knife-edge affixed to the top clip, and a similar knife-edge was affixed to the bottom clip, and on this rested one member of a compound lever, connected with the top lever, and so arranged that by altering a thumb-screw it would multiply three, five, or fifteen times. In a similar way, by an arrangement of pulley-blocks and cord, the instrument could be adapted to register the operation of a weight of 100 tons, or of 2 or 3 tons. As Professor Unwin had said, it was the behaviour up to the elastic limit which was of importance in actual practice, and he had referred to the case of a bridge sinking 20 ft., if that limit were exceeded; but he would remark that if there were such an elongation it would take place in some local bar which would relieve itself of the excessive stress to which it was exposed, and throw it on to the other bars of the bridge, and only after a repetition of such a strain on the whole of the bars successively would there be a sinking and deformation of the centre of the bridge. In actual machinery such a case seldom occurred, and remembering that a bar only lengthened a small amount, which would hardly be observable unless there were such a multiplication as he had mentioned, it occurred to him that where a bar broke that must have happened. Now if the load were relieved, and then it were repeated, the material would be more or less completely elastic up to the point which was before sufficient to break it down. If, after many applications of the load, there were no permanent increase of length, then the bar would stand the repetition of that strain indefinitely, and it was that capability of taking an infinite number of excessive stresses which was the really valuable quality of the bar; and it was as to this quality that information was required; with a view to know whether, when the elastic limit was passed and the strain relieved, there was an increase of permanent set. If the apparatus were so designed that it magnified those elongations which were within the elastic limit so much that one could be certain there was no further increase, it would give valuable information about the material.

Mr. W. Worly Beaumont said Professor Hearson would like to get a record of what took place in a piece of iron subject to a great number of repetitions of stress. A number of experiments had been made by Mr. Baker, the engineer of the Forth Bridge, the result of which was that he had come to the conclusion that a piece of iron, instead of indefinitely increasing in its elastic strength, decreased very rapidly after a certain number of those applications. When the number of applications was enormous, it would be rather difficult to get them recorded on a diagram of this kind, on account of the time it would take. He noticed in the diagram that the bar of brass gave a very different curve to that of any other material; and in an early part of the paper Professor Unwin spoke of the behaviour of iron and steel as to local contraction, and also as to the particular curve obtained in testing mild steel. He believed that drop was obtained with some of the soft irons, but not in so pronounced a degree as was shown on the mild steel diagram. It might be worth the consideration of those who were studying this subject, whether there might not be some connection between the composition of the materials and their behaviour in this respect; for instance, brass did not behave in that way in the slightest degree, while mild steel did in an excessive degree. Steel, it would seem, had a local extension when it began to give way, while brass showed this extension throughout its whole length. An explanation had been offered, assuming the material to be composed of bundles of fibrous crystals, and that these got into a certain position after a certain stress was brought to bear upon them, and in which they were better able to withstand the stress than before it was put on, and he thought this was to some extent supported by the way in which the material behaved under repeated stresses. With regard to the instruments which had been described, he thought that of Professor Unwin recommended itself by its simplicity and directness of action. It was an independent apparatus, with the pencil so arranged that there could be no slack in the wire which operated it, this being always under a slight tension. Again, he could very simply arrange it so as to have the vertical scale drawn on any scale he chose, and it occurred to him that by altering the speed at which the drum revolved he might change the form of the curve, and by giving an earlier movement to the barrel, he could show the peculiarities in the elastic part of the curve which were not visible in the vertical straight line. If, for instance, it were so arranged that the no alteration line, instead of being vertical, were slightly at an angle, steps would be observable which would perhaps indicate the point Professor Hearson mentioned as to a permanent extension taking place within the mean elastic limit. The instrument of Professor Kennedy, as shown, seemed to be very simple, but it imported a possible source of error by having two different materials in series, as Professor Kennedy put it, and a connecting medium between the test piece and the master bar. On the whole, he thought Professor Unwin's apparatus recommended itself by its simplicity in preference to some of the other very costly ones described.

Mr. ASHCROFT, being called upon, said all he could have done would have been to describe Professor Kennedy's machine, but this had already been done in a way which he could not improve upon. He might say, however, in answer to the last speaker, that the error he had referred to, occasioned by the distance piece between the two bars, was compensated for by an arrangement of levers, not shown in the diagram, but which he should be happy to point out on the model and explain.

The CHAIRMAN said he had no special knowledge of this subject, but one or two points had suggested themselves to him as a physicist. In the first place, as Professor Hearson had pointed out, it was the commencement of the strain which it was most important to record. In all cases of clutching and clipping there must be a little crushing of the object before the bite was perfected, and, of course, this point required attention. He was reminded by these results of those obtained in the Glasgow University laboratory, as to the tiring of wires which underwent a longitudinal strain, and their recovery from that condition, but he did not remember how far the experiments on massive bars gave results coincident with those of thin wires. There was also a point of interest as to the rate of loading; was any difference found in these stress and strain diagrams according to the rate at which the increasing load was applied. It would probably be a function of those steps and recoveries. Finally, as a physicist, he might say that the method which suggested itself to him would be such an arrangement as an optical lever combined with reflected light, in order to make the very smallest elongation of the bars visible, and perhaps a permanent record might be obtained by a revolving drum of sensitised paper. These were crude notions, but some of them might be worth consideration.

Professor UNWIN, in reply, said he was very glad that Professor Hearson had described his apparatus, because he had not seen it, and could not, therefore, give a very lengthy account of it. It was obviously a very ingenious one, and he himself had tried a very similar lever arrangement, only he did not adopt the compound lever. No doubt there were cases where it would be useful, but he did not think it would be of much use for the elongations within the elastic limit; his view being that not 15, but somethiug like 150 times magnification was required, and he did not think by any mechanical lever arrangement you could get such a magnifying power sufficiently accurate. That was the reason why he had not even tried anything of the kind. He believed there was only one action which could be adopted, and that was the roller as used by Professor Kennedy. He would not say much in reply about the bridge deflection, but he did not mean to say that the elastic limit was the only thing to pay attention to in testing; he rather wished to lay stress on the fact that it was one point of importance. On that point he thought he had some information even later than Professor Hearson's. A good deal of work had been done lately in Germany in putting together the results of Wohler's experiments, which had been going on night and day continuously for the last nine or ten years, bars being loaded and relieved once a second for twenty-four hours during every day in the week. He believed they were getting some light there by connecting up Wohler's limits of stress with the primitive elastic limit of bars. One thing seemed to be established, that if a bar were equally stressed in both directions the stress must not exceed the primitive elastic limit. He owed Mr. Ashcroft an apology for not mentioning his name in connection with Professor Kennedy's machine, which he knew he had taken large part in designing, and he was much obliged to Professor Kennedy for sending it. It was not really a complicated machine, though it looked so, and was not easily described. The Chairman had spoken of the experiments on the fatigue of wires at Glasgow, and some extremely careful experiments of the same kind had been made by Bauschinger with somewhat similar results. If you strained a bar a little above the breaking-down point, then took the load off and put it on again directly, both the breaking-down point and the elastic limit were lowered, but if it was left for twenty-four hours, they were raised. The rate of loading affected the diagram in this way, that if you increased the load very slowly the latter portion of the curve was slightly flattened. The Chairman had spoken of the optical lever, and he had used it, and so had Bauschinger, when he wanted exceedingly fine observations; but he did not see his way to adapting it to an autographic apparatus. If he could see his way to using sensitised paper in the way suggested it would be extremely convenient, because with an optical lever you could obtain any amount of magnification without error.

The CHAIRMAN then proposed a vote of thanks to Professor Unwin, which was carried unanimously, and the meeting adjourned.

CORRECTION.—Page 290, col. 2, l. 15, *for* 26,000,000, *read* from 6 to 7 millions.

Miscellaneous.

SILK CULTURE IN SIAM.

In a report issued by the Foreign-office on the condition of Siam, it is stated that the culture of silk is strictly confined to the numerous Laos settlements throughout the country, and to the Cambodians in the south-eastern provinces bordering on Cambodia; nowhere are any Siamese known to rear the silkworm. The reason generally given is that whilst the art of silk culture, which is deemed a difficult one, has been transmitted to the Laos through successive generations, the Siamese are in complete ignorance of it. The great centres of the production of silk in Siam are Korat, 130 miles to the north-east of Bangkok; and Battambong, 200 miles to the south-east. Beautiful cloths, sometimes of great value, are woven in Chiengmai, and a certain quantity of raw silk is said to be exported from Hluang Prabang, on the Mekong river, to Chiengtung, one of the principal Shan States. The production, however, is small in comparison with that of Cambodia and Annam, and the export is, consequently, unimportant, consisting entirely of so-called Korat silk. It is taken to the latter place in small quantities from the neighbouring Laos and Cambodian provinces, such as Buachum, Pimai, Suwanaphum, Sisakat, Khukan, Sangkha and Surin, and there sold, or more generally bartered for cotton and other goods, to Chinese traders, who re-sell it at Bangkok to the exporters. At present, half the number of families in a village composed entirely of Laos rear the silkworm, but they almost all, without any exception, weave their own cloths. The silk culture is confined solely to the women, who take a share even in the cultivation of the tree. A large proportion rear the silkworm only in the wet season, when the plant is in leaf, and, therefore, obtain the seed from the few who rear a small quantity throughout the year, barely sufficient to keep up the breed, or only a small quantity of leaves is furnished by the plants during the hot season. The tree is called by the Laos, *ton mon;* and the worm, *tua mon.* There are two kinds of tree, and it appears doubtful whether they were originally distinct. The large kind is similar to the mulberry tree, and in its full growth attains a height of from twenty to thirty feet. This tree is by no means common, as it is found very difficult to rear, requiring great care when young, though when it has firmly taken root it requires no attention, and is said to attain a great age. Like the European tree, it has a small white flower in cluster, but it bears no fruit. In Hluang Prabang, about four hundred and fifty miles to the north, it is said to bear a red berry, and is probably the same as the European black mulberry tree. It is reproduced from cutting, and is found to grow best on dry sandy soil. The common description of tree is much smaller, and consists of a stem about half an inch in diameter, with small branches at regular intervals. Its height is generally about five feet, but it sometimes reaches seven feet. The bark is similar to that of the large kind, and the leaf appears to differ only in size. It is planted on dry ground, and requires constant watering and some care until it has grown to a height of one or two feet, and is measured once a year, in the sixth month before it is cut. The shape of the leaf is cordate or deeply indented. Its size does not exceed two or three inches in the small kind, while that of the larger is often more than double. Both kinds bear leaf all the year round, but very little in the hot season. It is from the eighth to the eleventh month, that is to say, from June to September, that the new trees bear a sufficient quantity of such tender leaves as are most suitable for the young worms. The silkworm rearing season is, therefore, from the end of June to the end of September, and two broods are generally reared. The eggs are hatched in the period of ten days, the worms are then kept on the same piece of cloth on which the eggs have been laid by the moth for four or five days, when they are large enough to be taken off and placed on a round flat tray of bamboo wicker-work about three feet in diameter, with a rim one inch high, in which they are kept until ready to spin the cocoon. The wicker-work is not close, but sufficient space is kept for the litter to pass through without the worm falling off, and the basket is then called *takrĕng*; this precaution, however, is often neglected, and the ordinary baskets used for winnowing rice are commonly used. These are called *kadong* both by Siamese and Laos, but in the north the rim is generally higher, and they are then called *hô.* The worms are not fed for the first few days, they are then fed three times a day. They cast off the skin four times, and the size of the worm at the third casting of the skin is about an inch, and it is then of the ordinary greenish tint. The worms that are ripe are removed to a tray similar to the one described above, but having on its flat surface a number of concentric circles of bamboo trellis work about an inch and a-half high; there is thus between the circles a series of compartments one inch and a-half broad, in which the worms spread their web and spin the cocoon in the course of a day or night. This tray, called *tcho* by the Laos, as well as the other ones containing the worms or seeds, are all placed on a series of frames called *khĕng*, made in such manner as to prevent ants or other insects from molesting the worms or cocoons. The contrivance is very simple, and is constructed as follows. A series of four or five oblong frames are formed by four vertical pieces of bamboo, or sometimes rope, about four feet long, which are kept apart at intervals of about ten inches by horizontal pieces two feet long placed broadwise, and rather less than four feet long placed lengthwise. The whole is firmly attached, and the two vertical pieces on either side are tied together after the topmost tray, and the rope is made to pass through a cup, generally half a cocoanut, filled with water. The whole is then suspended to a horizontal pole which hangs from the ceiling in the corner of the common sitting-room or bedroom. In size, the Siamese cocoons compare unfavourably with the European kinds, being only about two-thirds as large. But in the Northern Laos provinces, where there are two rearing seasons, one in the late summer and the other in late autumn, the cocoons of the first produce are said to be of a larger size. The following is a description of the spinning machine in vogue in Siam. It is very simple, and consists of a thin piece of soft wood about two inches broad, bent in the shape of a horse shoe; about ten inches from its extremities a piece of wood of like thickness and breadth, and having a small hole in the middle, is fixed horizontally, and about six inches above it is a small winder placed horizontally in the same manner. The two extremities of the machine are fixed on two small flat pieces of wood, having a groove on the inner side, which enables it to be fixed on to the rim of an earthern pot. It thus stands over the mouth of the pot filled with boiling water, in which a number of cocoons have been thrown. The spinner sits before a small fire-place, on which is placed the pot with the spinning-machine fixed firmly on to it, and with a stick having a small slit at the top, shakes the cocoons in such manner as to collect the threads of about half the number in the pot. Having twisted them with the hand into a single thread, it is passed through the small hole and fastened loosely over the winder. It is then pulled out with the right hand, the winder being thus caused to revolve, and is gradually heaped up in a basket close at hand. In the left hand the spinner holds the stick described above, with which to keep down the filament when it becomes entangled. This machine is called by the Laos *mak khueng talok*, and its height is generally about three feet. The method of reeling is as follows:—The thread is reeled on a winder twenty inches long, fixed horizontally on a stand, on which the thread is improved by scraping off with a knife where it appears irregular, and by removing any blemishes. It is then re reeled on another winder made of two sticks, fixed horizontally on the extremities of a piece of wood about two feet high. This is held in the middle with the left hand, and the thread wound in zigzag fashion with the right over the extremities of the cross sticks. The skein thus takes the shape in which it is generally sold. Sometimes this winder is replaced by another, formed of four cross pieces instead of two, the extremities of which are joined with string; it is then laid horizontally on a stand, is furnished with a handle, and the thread is reeled over the strings. This winder, called *ra wing*, is used both by the Laos and the Siamese. When it is required to twist a double thread or tram another instrument comes into use. A narrow stand, about four feet long, contains at one end a large wheel turned by a handle; a string is passed over the latter and round a piece of iron a foot in length, projecting from the stand on one side and rounded at the end. Some rough cotton is wound over the middle part in which the string catches so that in turning the wheel the iron point revolves quickly. The two or more threads are tied together to the extremity of the iron instrument, and this in revolving twists them firmly together.

BURMESE ARMS.

Long matchlocks, with very small stocks, are the only Burmese firearm, besides the short broad cannon used in salutes. The former carry a long distance, and are not fired from the shoulder, but from the side of the head, nearly on a level with the ear. Attached to the small square embroidered bag that every Shan carries over his shoulder, is a small powder-flask of the shape of a miniature horn, flattened and distended at the point, which is open, but has a flat piece of horn which fits into it, and is prolonged backwards across the curve of the flask, to the base of which it is firmly fastened. Downward pressure on the free portion over the curve raises the lid-like anterior extremity of this primitive spring, and allows the powder to run out in driblets. More capacious powder-flasks are made of the horns of cattle, but they are only used on a long expedition. They are suspended from a broad red belt, ornamented with lines and rosettes of cowries, and with tufts of red hair round the margins. The horn of the serrow, artificially sharpened at the point, is usually found attached to the shoulder-bag, and is used as a borer, while its base may be bound with brass, and closed with a lid as a lime or opium box.

A description of the costume of the Shans generally would be very incomplete were the dáh unnoticed. This has a blade 2½ ft. to 3 ft. long, gradually expanding from the hilt towards the almost square point, which is about 2½ in. broad. The handle is of wood, bound with cord, and ornamented with silver foil, with a tuft of red goat's hair stuck in the hilt. The wooden scabbard covers only one side of the blade, and a hoop of ratan, bound with red cloth, is attached to its upper third, and worn over the right shoulder.

The Kakhyens have a very ingenious way of striking fire by the sudden and forcible descent of a piston in a closed cylinder. There is a small cup-shaped cavity at the end of the piston-rod into which tinder is inserted. The piston is then introduced into the cylinder, which it tightly fits, and by a blow is made to descend with great rapidity and force, and is as rapidly withdrawn, when the little pellet of tinder is found to have become ignited: a beautiful but simple experiment, illustrating the evolution of a very large amount of heat by the sudden compression of the air in the piston. These instruments are not more than four inches long, and are in general use.

RAILWAYS OF EUROPE.

According to a statement in a recent *Revue Generale des Chemins de Fer*, the length of railways open for traffic in Europe, on December 31st, 1884, as compared with the mileage open at the same date in 1883, Germany heads the list with 36,737 kilos. of railway, as against 35,908 kilos. in December, 1883; increase during the year, 829 kilos., or 2·31 per cent. Next follows France with 31,216 kilos., against 29,714 kilos.; increase 1,502 kilos., or 5·05 per cent. Great Britain and Ireland, 30,514 kilos., against 30,179 kilos.; increase, 1·11 per cent· Russia and Finland, 25,391 kilos., against 24,888 kilos.; increase 503 kilos., or 2·02 per cent. Austria 22,016 kilos., against 20 857 kilos.; increase 1,249 kilos., or 5·99 per cent. Italy, 9,925 kilos., against 9,445 kilos.; increase 470 kilos., or 4·97 per cent. Spain, 8,663 kilos., against 8,251 kilos.; increase 412 kilos., or 4·99 per cent. Sweden and Norway, 8,162 kilos., against 7,960 kilos.; increase 202 kilos. or 2 54 per cent. Belgium, 4,319 kilos., against 4,273 kilos.; increase 46 kilos., or 1·08 per cent. Switzerland, 2,761 kilos., against 2,750 kilos.; increase 11 kilos., or 0·40 per cent. Holland and Luxemburg, 2,654 kilos., against 2,521 kilos.; increase 133 kilos., or 5·28 per cent. Denmark, 1,944 kilos., against 1,813 kilos.; increase 131 kilos., or 7·23 per cent. Roumania, 1,602 kilos., against 1,520 kilos.; increase 82 kilos., or 5·39 per cent. Portugal, 1,527 kilos., against 1,494 kilos.; increase 33 kilos., or 2·21 per cent. Turkey, Bulgaria, and Roumelia do not show an increase in the mileage of their railways during 1884, which had a length of 1,394 kilos. in December, 1883; nor do the railways of Servia, with 244 kilos. Greece, on the contrary, increased her railways from 22 kilos. in 1883, to 175 kilos. in 1884. The total length of European railways on December 31st, 1884, was 189,334 kilos., compared with 182,999 kilos. on December 31st, 1883. The aggregate increase was 6,335 kilos., or 3·46 per cent.

Correspondence.

SOME POINTS IN ELECTRICAL DISTRIBUTION.

We regret that we were unable to attend the meeting of the Society held on the 19th inst., but having seen the report of Professor Forbes' paper on the above subject in the last number of the Society of Arts' *Journal*, we wish to draw attention to two statements made by him, and which we are surprised to see were not commented upon in the discussion which followed. The observations we wish to make relate to that part of his paper touching on secondary generators, and in which mention is several times made of the Grosvenor Gallery installation erected under our supervision for our clients, Sir Coutts Lindsay & Co., Limited. In speaking of *parallel distribution* by generators, Professor Forbes seems to labour under the impression that the same difficulties are met with as is the case in ordinary parallel lighting; viz., the fall of potential along the line, varying in proportion as the current is increased or diminished by generators being turned off or on. This fall of potential is dependent on the ratio that the amount of loss on the line itself bears to the maximum amount of work that is carried by the line. In the case of direct currents, this ratio may be 10 to 20 per cent., while in the case of high tension currents it can be reduced as low as 1 to 1·5 per cent.

As the variations in potential must be proportional to the variations of the amount of work lost on the line, in the case of direct currents, where this variation may reach 20 per cent., a corresponding *pro rata* variation in potential must be met in the manner mentioned by Professor Forbes; but where this variation is only 1 to 1·5 per cent., such precautions are not required, as generators or transformers in parallel are capable of maintaining practically the same potential in their secondary circuits, no matter where their position may be, or how the load along the line may be varied.

Again, speaking of generators in series, the lecturer stated that if "a double wire be used to prevent affecting telephones, it is half the weight;" but we fail to understand how he would propose to thus obviate induction on telephone lines, without at the same time doubling the weight of the entire conductor. We notice he gave no diagram of this proposed arrangement.

Another matter we cannot refrain from referring to is that of the automatic regulation of the secondary current when the generators are run in series.

The *modus operandi* seen by Professor Forbes, though practically originated by us, did not appear as successful in our estimation as it seems to have done in his, and for practical purposes has had to be abandoned.

KENNETH MACKENZIE,
REGINALD BROUGHAM.

15, Great George-street, S.W.

COLONIAL POSSESSIONS.

Mr. P. L. Simmonds writes to correct two items in the report of his remarks in the discussion on Dr. Mann's paper. Page 290, col. 1, line 13, the amount of paper should be three-quarters of a million instead of three millions. Line 45, 404,000,000 *tons* should be 404,000,000 *lbs.*

[A letter on Machinery in Mines has been received from Mr. Isaac Shone.]

General Notes.

TALL CHIMNEYS.—In reference to the note on the Mechernich chimney (see *ante* p. 175), Mr. H. Stopes draws attention to two specially tall chimneys in Glasgow—Townsend's, 454 feet; Tennant's, 235 feet.

THE HUNGARIAN TEXTILE INDUSTRY.—The *Wochenscheft für Spinnerei und Weberei* remarks that the Hungarian textile industry consists, as a whole, of remains of past activity and of a few more or less successful new manufactures, which have been established under the auspices of the Government. The entire textile industry employed in 1880 about 25,000 workmen and 15,000 assistants; of this number 15,000 were linen weavers and 5,000 assistants.

PARISIAN MANUFACTURES.—The trade in "Articles de Paris," such as artificial flower fashions, toys, dolls, opera glasses, brushes, fans, &c., of which four-fifths were in the hands of Parisian manufacturers, has declined considerably during the last ten years, as may be seen by the following statistics of the value of the exportation of these goods:—

	Articles de Paris.	Artificial Flowers and Fashions.
	Frs.	Frs.
1875 ……	168,411,000 ..	42,189,000
1876 ……	163.720,000 ..	35,804,000
1877 ……	150,861,000 ..	36,678,000
1878 ……	149,125,000 ..	30,255,000
1879 ……	141,879,000 ..	30,113,000
1880 ……	159,092,000 ..	32,436,000
1881 ……	147,282,000 ..	45,003,000
1882 ……	102,787,000 ..	38.547,000
1883 ……	104.529,000 ..	36,208,000
1884 ……	91,930,000 ..	27,602,000

A further falling off of about two millions of francs in each category has taken place during the first ten months of the present year as compared with the corresponding period of last year.

LIQUID FUEL FOR STEAMSHIPS.—The system of oil-burning apparatus recently described by us as having been fitted on board the *Himalaya* steamship has been applied to a vessel recently launched by Messrs. Wigham, Richardson, and Co., of Newcastle-on-Tyne. The steamer, which is intended for the Black Sea trade, and to be permanetly oil-burning, has her water-ballast tanks divided up, and made available for the storage of her fuel. She has also other storage tanks built into the ship on each side of the engine-room, all these being connected by pipes to the small feed-tanks situated above the boiler. A large supply pipe connected through valves to the storage tanks allows of the vessel being being filled up with fuel in a very short space of time. The oil-burning apparatus has been fitted by the Tarbutt Liquid Fuel Company, of 75, Lombard-street, London, and is similar to that adopted on board the *Himalaya*, which recently made her successful trial trip from London to Granton and back on the new fuel. A trial of the apparatus has just been satisfactorily completed at Messrs. Wigham, Richardson, and Co.'s works, which was attended by representatives from some of the leading shipbuilding and engineering works on the Tyne, who are evincing great interest in this most recent development of the liquid fuel question. A number of applications of this system are now being made to marine and stationary boilers, stills, and plate-heating furnaces.—*The Times*.

MEETINGS OF THE SOCIETY.

ORDINARY MEETINGS.

Wednesday evenings, at Eight o'clock:—

MARCH 3.—"Calculating Machines." By C. V. BOYS.

MARCH 10.—"The Experiments with Lighthouse Illuminants at the South Foreland." By PRICE EDWARDS. Lord RAYLEIGH, Secretary of the Royal Society, will preside.

MARCH 17.—"Domestic Electric Lighting." By W. H. PREECE, F.R.S.

APRIL 14.—"The Treatment of Sewage." By Dr. C. MEYMOTT TIDY.

FOREIGN AND COLONIAL SECTION.

Tuesday evenings, at Eight o'clock:—

MARCH 2.—"Bechuanaland and Austral Africa." By JOHN MACKENZIE, late Deputy Commissioner for Bechuanaland. Sir HENRY BARKLY, K.C.B., G.C.M.G., F.R.S., will preside.

MARCH 23.—"Canada and its National Highway." By ALEXANDER BEGG.

APRIL 13.—

MAY 18.—"The Commerce and Industries of New South Wales." By EDWARD COMBES, C.M.G., President of the Board of Technical Education of New South Wales.

APPLIED CHEMISTRY AND PHYSICS SECTION.

Thursday evenings, at Eight o'clock:—

MARCH 11.—"Films and Paper as Substitutes for Glass in Photography." By LEON WARNERKE. Captain W. DE W. ABNEY, F.R.S., will preside.

MARCH 25.—"Certain Methods for the Utilisation of Refuse and Dust Fuels." By WALTER G. MCMILLAN, F.C.S., Demonstrator of Metallurgy, King's College, London.

APRIL 8.—

MAY 13.—"The Scientific Development of the Coal Tar Colour Industry." By Professor R. MELDOLA, F.C.S.

INDIAN SECTION.

Friday evenings, at Eight o'clock:—

MARCH 19.—"Experiences on the Afghan

Frontier." By WILLIAM SIMPSON. Col. HENRY YULE, C.B., will preside.

APRIL 2.—"The History of Archæology in India." By JAMES GIBBS, C.S.I., C.I.E., late Member of the Viceroy's Council. Sir GEORGE BIRDWOOD, C.S.I., Member of the Council, will preside.

MAY 7.—"Indian Manufactures from a Practical Point of View." By B. H. BADEN POWELL, C.I.E.

The above dates are liable to alteration.

CANTOR LECTURES.

The Third Course will be on "Science Teaching" By PROF. F. GUTHRIE, F.R.S.

Lecture III.—March 1.—Teaching Physics.

ADDITIONAL LECTURES.

"Japanese Art Work." BY ERNEST HART.

Lecture I.—May 4.—Japanese Metal Work.

Lecture II.—May 11.—Japanese Porcelain and Pottery.

Lecture III.—May 18.—Japanese Picture Books and Drawings.

MEETINGS FOR THE ENSUING WEEK.

MONDAY, MARCH 1...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. (Cantor Lectures.) Prof. F. Guthrie, F.R.S., "Science Teaching." (Lecture III.)

Farmers' Club, Inns of Court Hotel, Holborn, W.C., 4 p.m. Mr. J. M. McLaren, "Farm Machinery."

Royal Institution, Albemarle-street, W., 5 p.m. General Monthly Meeting.

Engineers, Westminster Town-hall, S.W., 7½ p.m. Mr. E. S. Bellasis, "The Roorkee Hydraulic Experiments."

Chemical Industry (London Section), Burlington-house, W., 8 p m. 1. Mr. Redwood, "Viscosimetry." 2. Mr. T. B. Lightfoot, "Ice-making and Cooling Machinery."

British Architects, 9, Conduit-street, W., 8 p.m. To receive report of Council in award of medals and prizes, and to award medals for architectural competitions.

Medical, 11, Chandos-street, W., 8½ p.m. Anniversary.

Victoria Institute, 7, Adelphi-terrace, W.C., 8 p.m. Professor Maspero, "The Geographical Names on the list of Thoutmos III., found in Syria," being a Paper giving the results of many years' investigation.

London Institution, Finsbury-circus, E.C., 5 p.m. Prof. W. K. Parker, "Birds, their Structure, Classification, and Origin."

Medical and Chirurgical, 53, Berners-street, Oxford-street, W., 8½ p.m. Annual Meeting.

TUESDAY, MARCH 2...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. (Foreign and Colonial Section.) Mr. John Mackenzie, "Bechuanaland and Austral Africa."

Royal Institution, Albemarle-street, W., 3 p.m. Mr. C. T. Newton, "The Unexhibited Portion of the Greek and Roman Sculptures in the British Museum." (Lecture III.)

Central Chamber of Agriculture (at the HOUSE OF THE SOCIETY OF ARTS), 11 a.m.

Civil Engineers, 25, Great George-street, S.W., 8 p.m. Adjourned discussion on Mr. L. F. Vernon-Harcourt's paper, "The River Seine."

Pathological, 53, Berners-street, Oxford-street, W., 8½ p.m.

Biblical Archæology, 9, Conduit-street, W., 8 p.m.

Zoological, 11, Hanover-square, W., 8½ p.m. 1. The Secretary, "Additions to the Menagerie in February." 2. Prof. R. Collett, "A New Pendiculate Fish from the Sea off Madeira." 3. Mr. Sclater, "Note on the External Characters of *Rhinoceros simus.*

WEDNESDAY, MARCH 3...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. Mr. C. V. Boys, "Calculating Machines."

Entomological, 11, Chandos-street, W., 7 p.m.

Archæological Association, 32, Sackville-street, W., 8 p.m. 1. Mr. Thomas Morgan, "Notes on Haslemere." 2. Mr. R. Mann, "Roman Villa at Box."

Obstetrical, 53, Berners-street, 8 p.m.

THURSDAY, MARCH 4...Royal, Burlington-house, W., 4½ p.m.

Antiquaries, Burlington-house, W., 8½ p.m.

Linnean, Burlington-house, W., 8 p.m. 1. Sir John Lubbock, "Observations concerning Seedling Plants." 2. Professor T. Spencer Cobbold, "*Strongylus Arnfieldi* and *O. tetracanthus.*" 3. Mr. Geo. Murray, "Reproduction of Rhipilia and New Species R. Andersoni."

Chemical, Burlington-house, W. 8 p.m. Ballot for the election of Fellows. 1. Mr. S. U. Pickering, "The Influence of Temperature on the Heat of Chemical Combination." 2. Mr. N. Collie, "The Action of Heat on the Salts of Tetrethyl Phosponium." 3. Dr Letts and Mr. N. Collie, "A New Method for the preparation of Tin Tetrethyl." 4. Dr. Alfred Senior, "Contribution to the History of Cyanuric Chloride and Cyanuric Acid." 5. Mr. Harold Fries, "Contributions to the Knowledge of Cyanuric Derivatives"

London Institution, Finsbury-circus, E.C., 5 p.m. Prof. Bentley, "The Life of a Plant."

Society for the Encouragement of Fine Arts, 9, Conduit-street, W., 8 p m. Mr. W. Cave Thomas, "The Proportions of the Beau Ideal of the Human Form."

Parkes' Museum of Hygiene, 74A, Margaret-street, 8 p.m. Mr. Shirley Murphy, "Metropolitan Defences against Infectious Diseases."

South London Photographic (at the HOUSE OF THE SOCIETY OF ARTS), 8 p.m.

Royal Institution, Albemarle-street, W., 8 p.m. Prof. W. Boyd Dawkins, "The Ancient Geography of Britain."

Archæological Institution, 16, New Burlington-street, W., 4 p.m.

FRIDAY, MARCH 5...United Service Institute, Whitehall-yard, 3 p.m. Rear-Admiral W. Arthur, "The Results of the Naval Operations on Berehaven—Attack and Defence by Torpedo Boats."

Royal Institution, Albemarle-street, W., 8 p.m. Weekly Meeting. 9 p.m. Professor A. Macalister, "Anatomical and Medical Knowledge of Ancient Egypt."

Philological, University College, W.C., 8 p.m. 1. Mr. B. Dawson, "Notes on the Revised Version of the New Testament." 2. Rev. R. Morris, "The Blunders in Miss L. T. Smith's edition of the Yorkshire plays."

SATURDAY, MARCH 6 ... Royal Institution, Albemarle-street, W., 3 p.m. Rev. C. Taylor, "The History of Geometry. The Greeks and the Moderns."

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FRIDAY, MARCH 5, 1886.

All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

NOTICES.

CANTOR LECTURES.

The third and concluding lecture of the third course of Cantor lectures was delivered on Monday evening, 1st inst., by Prof. GUTHRIE, F.R.S., the special subject of the lecture being the Teaching of Physics. On the motion of the Chairman a vote of thanks to the lecturer for his course of lectures was carried unanimously.

The lectures will be printed during the Easter recess.

APPLIED CHEMISTRY & PHYSICS SECTION.

Thursday, February 25, 1886; Sir HENRY E. ROSCOE, F.R.S., M.P., in the chair.

The paper read was "Photography and the Spectroscope in their application to Chemical Analysis," by Professor W. N. HARTLEY, F.R.S.

The report of the meeting will be given in next week's number of the *Journal.*

ALBERT MEDAL.

The Council will proceed to consider the award of the Albert Medal for 1886 early in May next. This medal was struck to reward "distinguished merit for promoting Arts, Manufactures, or Commerce," and has been awarded as follows :—

In 1864, to Sir Rowland Hill, K.C.B., F.R.S., "for his great services to Arts, Manufactures, and Commerce, in the creation of the penny postage, and for his other reforms in the postal system of this country, the benefits of which have, however, not been confined to this country, but have extended over the civilised world."

In 1865, to his Imperial Majesty, Napoleon III., "for distinguished merit in promoting, in many ways, by his personal exertions, the international progress of Arts, Manufactures, and Commerce, th proofs of which are afforded by his judicious patronage of Art, his enlightened commercial policy, and especially, by the abolition of passports in favour of British subjects."

In 1866, to Michael Faraday, D.C.L., F.R.S., "for discoveries in electricity, magnetism, and chemistry, which, in their relation to the industries of the world, have so largely promoted Arts, Manufactures, and Commerce."

In 1867, to Mr. (afterwards Sir) W. Fothergill Cooke and Professor (afterwards Sir) Charles Wheatstone, F.R.S., "in recognition of their joint labours in establishing the first electric telegraph."

In 1868, to Mr. (now Sir) Joseph Whitworth, LL.D., F.R.S., "for the invention and manufacture of instruments of measure and uniform standards by which the production of machinery has been brought to a state of perfection hitherto unapproached, to the great advancement of Arts, Manufactures, and Commerce."

In 1869, to Baron Justus von Liebig, Associate of the Institute of France, For. Memb. R.S., Chevalier of the Legion of Honour, &c., "for his numerous valuable researches and writings, which have contributed most importantly to the development of food economy and agriculture, to the advancement of chemical science, and to the benefits derived from that science by Arts, Manufactures, and Commerce."

In 1870, to Ferdinand de Lesseps, "for services rendered to Arts, Manufactures, and Commerce, by the realisation of the Suez Canal."

In 1871, to Mr. (afterwards Sir) Henry Cole, K.C.B., "for his important services in promoting Arts, Manufactures, and Commerce, especially in aiding the establishment and development of Science and Art, and the South Kensington Museum."

In 1872, to Mr. (now Sir) Henry Bessemer, F.R.S., "for the eminent services rendered by him to Arts, Manufactures, and Commerce, in developing the manufacture of steel."

In 1873, to Michel Eugène Chevreul, For. Memb. R.S., Member of the Institute of France, "for his chemical researches, especially in reference to saponification, dyeing, agriculture, and natural history, which for more than half a century have exercised a wide influence on the industrial arts of the world."

In 1874, to Mr. (afterwards Sir) C. W. Siemens, D.C.L., F.R.S., "for his researches in connection with the laws of heat, and the practical applications of them to furnaces used in the Arts; and for his improvement in the manufacture of iron; and generally for the services rendered by him in connection with economisation of fuel in its various applications to Manufactures and the Arts."

In 1875, to Michael Chevalier, "the distinguished French statesman, who, by his writings and persistent exertions, extending over many years, has rendered essential service in promoting Arts, Manufactures, and Commerce."

In 1876, to Sir George B. Airy, K.C.B, F.R.S., Astronomer Royal, "for eminent services rendered to Commerce by his researches in nautical astronomy, and in magnetism, and by his improvements in the application of the mariner's compass to the navigation of iron ships."

In 1877, to Jean Baptiste Dumas, For. Memb. R.S., Member of the Institute of France, "the distinguished chemist, whose researches have exercised a very material influence on the advancement of the Industrial Arts."

In 1878, to Sir Wm. G. Armstrong, C.B., D.C.L., F.R.S., "because of his distinction as an engineer and as a scientific man, and because by the development of the transmission of power—hydraulically—due to his constant efforts, extending over many years, the manufactures of this country have been greatly aided, and mechanical power beneficially substituted for most laborious and injurious labour.'

In 1879, to Sir William Thomson, LL.D., D.C.L., F.R.S., "on account of the signal service rendered to Arts, Manufactures, and Commerce, by his electrical researches, especially with reference to the transmission of telegraphic messages over ocean cables."

In 1880, to James Prescott Joule, LL.D., D.C.L., F.R.S., "for having established, after most laborious research, the true relation between heat, electricity, and mechanical work, thus affording to the engineer a sure guide in the application of science and industrial pursuits."

In 1881, to August Wilhelm Hofmann, M.D., LL.D., F.R.S., Professor of Chemistry in the University of Berlin, "for eminent services rendered to the Industrial Arts by his investigations in organic chemistry, and for his successful labours in promoting the cultivation of chemical education and research in England."

In 1882, to Louis Pasteur, Member of the Institute of France, For. Memb. R.S., "for his researches in connection with fermentation, the preservation of wines, and the propagation of zymotic diseases in silk worms and domestic animals, whereby the arts of wine-making, silk production, and agriculture, have been greatly benefited."

In 1883, to Sir Joseph Dalton Hooker, K.C.S.I., C.B., M.D., D.C.L., LL.D., F.R.S., "for the eminent services which, as a botanist and scientific traveller, and a Director of the National Botanical Department, he has rendered to the Arts, Manufactures, and Commerce by promoting an accurate knowledge of the floras and economic vegetable products of the several colonies and dependencies of the Empire."

In 1884, to Captain James Buchanan Eads, "the distinguished American engineer, whose works have been of such great service in improving the water communication of North America, and have hereby rendered valuable aid to the commerce of the world."

In 1885, to Mr. Henry Doulton, "in recognition of the impulse given by him to the production of artistic pottery in this country."

Proceedings of the Society.

FOREIGN & COLONIAL SECTION.

Tuesday, March 2nd, 1886; HYDE CLARKE in the chair.

The paper read was—

BECHUANALAND AND AUSTRAL-AFRICA.

By JOHN MACKENZIE,

Late Deputy Commissioner of Bechuanaland.

INTRODUCTION.

To reach Bechuanaland now is a much easier thing than it was some 28 years ago. After 19 days of a most pleasant ocean voyage you find yourself at Cape Town. If your object is to proceed at once inland, two days' railway travelling will bring you to Kimberley, the present terminus of the South African railway system. Thus in, say, 22 days you can exchange London for Kimberley. Now, in 1858, when I performed my first voyage to South Africa, the Government contract allowed the Steamship Company 42 days to perform the voyage to the Cape; and we thought we had reason to congratulate ourselves when we reached Table Bay in 38 days. In 1871, after having visited England, I performed a second voyage to Cape Colony, this time on board one of those occasional steamers which then carried passengers, cargo, and mails, to South Africa. The passage was made in 27 days; and so delighted were the Cape people, that they gave the captain of the vessel a complimentary dinner. But now we can go to the Cape in half the time it took in 1858; and we are assured that improvements in machinery will still further lessen the time required.

The contrast is even greater with regard to the means of inland travelling in the Cape Colony. In 1858, the traveller entered his ox-waggon in Cape Town, and performed his long journey at the rate of, say, 25 miles per day, exclusive of delays caused by strayed cattle, want of grass, or flooded rivers. In those days six weeks or two months were usually spent by the most successful traveller in accomplishing the distance which is now gone over in two days.

The splendid Houses of Parliament, which have been recently completed, are an ornament to Cape Town, and do credit to the colony. The breakwater and docks, which are of inestimable service to the shipping of all nations, have been made in the interval to which I am referring. Instead of anchoring in Table Bay, the steamer now proceeds into dock, and the passenger leaving the vessel finds himself at once on *terra firma*. Should repairs be needed to a vessel, it can be placed high and dry for that purpose. Many travellers proceed to Port Elizabeth, and land there. At this busy port the enterprising merchants have not succeeded in their breakwater schemes—and the landing of passengers and goods still takes place by boats. But no part of South Africa testifies more to the influence of intelligence, energy, and capital, than the town of Port Elizabeth itself. Situated on a cheerless and unproductive sand-bank, it might have been supposed that the commercial men would have been content with the roughest accommodation, in the hope that having gathered what is called a fortune the merchant would carry it away to happier surroundings. Instead of this, the public buildings of Port Elizabeth are the finest in the colony, always excepting the magnificent Houses of Parliament recently built at Cape Town; and the residences of the merchants of "the Bay" show what refined taste and abundant wealth can do in changing a sandy waste into a well-watered neighbourhood, where you have house after house surrounded by its own trees and its own flower-garden. It is thus quite evident that the Port Elizabeth merchants have generally been content to make their home there, as the Cape merchants do in the lovely environs of Cape Town; and their children in such cases grow up to regard themselves as true sons of the soil, and members of the great colonial family of England.

We cannot delay to describe the leading towns of Cape Colony, nor can we speak about Natal or any of the Free States to-night. The railway takes us to Kimberley, where the traveller visits the "great hole," as some one called the diamond mine, which is in the middle of the town of Kimberley. It was my own experience to travel over this diamondiferous district long before diamonds were discovered, and I did not even dream of the wealth which lay beneath my feet. It was a wild, almost unoccupied, country, fitted for grazing purposes only after rain had fallen, as there were no perennial springs in the neighbourhood. Hence it was afterwards called the "dry diggings," to distinguish it from the diamond mines situated on the bank of the Vaal river. But the "diggings" were not long "dry." Wells were sunk, water was found everywhere, some of it good, in other cases too brackish for table use, but suitable enough for washing out the diamonds from the "blue stuff" in which they are found. The enterprising Kimberley people were not satisfied with these wells, so a water company was formed, and the water of the Vaal river has been carried through some twenty miles of piping from the river to Kimberley, where it is much appreciated. The consequence is that the graceful verandahs and flower gardens which characterised Kimberley, even in the early days, when it was only a "camp," are now fresh and flourishing, and trees are growing up apace. There is no town in South Africa which is so like, and yet so unlike, an English town as Kimberley. The cabs, the shops, the evident bustle and push of business, remind you of England. But not so the "great hole" in the centre of the town—the singular mixture of races and of languages, and the strange vehicles which meet you in the street, including the huge buck-waggon with its immense load of wool or of imported goods, and some sixteen oxen in front of it; the smart travelling waggon of the farmer, which contains his family and also the farm produce which he has brought for sale; the regulation "carriage and pair" of some successful man, only with a picturesque Malay seated as driver; the smart Cape cart with its lively horses; the familar donkey-cart with fruit and vegetables, only here accompanied by a shouting coolie. The importance of Kimberley is increased at present on account of its being the terminus of the South African north-going railway.

A GLANCE AT THE PAST.

Before we proceed into Bechuanaland, it will be necessary to our purpose this evening to bring forward, as briefly as possible, the salient points of Cape history, and especially of our connection with it, and with South Africa generally. We are always prepared for divergencies of opinion, but we are totally unprepared to accept of mis-statement, or distortion, or ignoring of historical fact, and then be asked to agree to some conclusion based on such insecure foundation. I wish the truth to be known concerning our past doings in South Africa. We have made mistakes, but we have also done a great work there, which, I find, is little understood.

It has, for instance, been recently asserted by a historian and traveller that "the Cape Colony was originally a Dutch colony;" and that "the Dutch throve and prospered, and continued to thrive and prosper till the close of last century"*—that is, till the country came into the hands of the English. Is this true? Was there such prosperity last century? Has there been retrogression since the country came into English hands? No. The very opposite of all this is the truth, as every patient student of South African affairs is aware. Listen to a reliable historian. "For nearly a century and a half," that is, up to the coming of the English, "the Cape was a mere mercantile settlement of the Dutch East India Company, who held a monopoly of trade, and checked and prevented the formation of what is now understood as a colony. It is necessary to bear this in mind when instituting a comparison between the age and progress of the Cape of Good Hope and the remarkable advancement of the Anglo-Saxon communities in America and Australia. The latter, from the outset of their career, enjoyed the favourable auspices of political freedom and unfettered industrial enterprise; but the early settlers in South Africa found themselves trammelled and repressed by a government which has been well described as 'in all things political purely despotic, and in all things commercial purely monopolist.'"†

While this despotic government was administered by the officers of the Dutch East India Company, the European inhabitants were, from the first, of many nationalities; the original mode of obtaining "colonists" being to grant a discharge to such of the company's soldiers or servants as were married, of good character, and Protestants; the soldiers of the Company hailing from other Continental countries, as well as from Holland. Their numbers were augmented by political exiles, who were sent to South Africa by the Batavian Government. These colonists, or burghers, suffered the most grinding oppression at the hands of the Dutch Company, which occupied the Cape for its own advantage, and not for the benefit of those who were still virtually its servants. So hopelessly hard was the oppression of the Company, that colonists, or burghers, were in the habit of escaping from the Cape altogether, as stowaways in ships; others proceeded into the interior of the country so far as to be beyond the reach of their oppressors. Petitions to Holland for redress were mostly unavailing, as they were usually referred back again to the local officers whose conduct was complained of. When all that these poor people wanted was but a fair price for the fruit of their labour, and when their petition was signed by the whole body of the burghers, "not one excepted," their remonstrance, in the eyes of the Company's officers, was but mere sedition and mutiny; and they were warned that if they presented such papers in the future, severe measures would be provided against the same. With no fair market for their industry, industry itself declined. Burghers pushed into the wilderness, with a few cattle, resolved to live on the abundant game rather than be the serfs of the Company. When they came under the English, the small European community at the Cape retained but little of their own European civilisation. Many of them lived in mere huts or hovels, their clothing was mostly the dressed skins of the game which had been killed for food, and their blankets to protect them from the keen Cape winter nights were fur-skins stitched like the native kaross. As the number of malcontents increased, while the Dutch Company's officers yielded nothing, but strove to crush opposition by occasionally seizing and summarily transporting the leaders as "useless persons," an open rupture took place, and a "free republic" was proclaimed in the town of Swellendam, where the people proceeded to elect what they called a National Assembly. A local government was also set up at Graaff Reinet, then the most northerly European town, the inhabitants having previously expelled their landdrost or magistrate. The central authority at the Cape was paralysed by such determined opposition, and was unable to move a step to put it down. Such was the actual condition of things at the Cape when it passed into the hands of the English. Be it understood that these malcontents made no opposition to the establishment of the English Government—the people of Graiff Reinet actually sending a deputation to the Cape to tender their allegiance. The English Government announced to the burghers that all monopoly should cease, and that trade should be free throughout the country. Instruments which had been in use for the public torture of prisoners were removed from the streets by the English, and a more humane system commenced. The prosperity of the Cape Colony dates from this period, and as we have seen, Cape colonists declare that, for all practical purposes, this ought fairly to be regarded as the date of the establishment of the Cape Colony, as a colony.

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* "Oceana," by J. A. Froude. Longmans & Co. p. 37.

† "South Africa, Past and Present." J. Noble. Longmans & Co.

Let me clear away another misapprehension. The English twice conquered the Dutch at the Cape. It is true the Prince of Orange, then a refugee in England, requested that the Cape should be handed over to the English; but this was not done. The Company's officers at the Cape had no instructions from their masters, the directors in Holland, and refusing to obey the command of an exiled prince, the place was taken by force. It is amazing how certain English writers take sides against their own countrymen—not merely pointing out their wrong-doings, which were a good service, but raising a prejudice against them in the most unwarranted way. I have spoken of the first taking of the Cape. It was given up again by the English in 1803, but did not again revert to the Dutch East India Company. The Cape was now for the period of three years a Dutch colony, under the Government of Holland. But when the European war broke out again, an English force was sent to the Cape for the same reason as before, to prevent a naval position of supreme importance from falling into the hands of the French. On this occasion our force was opposed not by the Dutch Company but by the force of the Dutch Government, assisted by Colonial burghers, under General Janssens. After an engagement, in which his army was driven back, the Dutch General and Governor capitulated, the English General cheerfully yielding the most liberal terms to the Dutch force and to the Colonists. The attacking party was about 4,000, and the defenders were 3,000 in number. It is asserted, on what evidence I am entirely at a loss to know, that the Cape colonists yielded in the belief that the occupation by the English would be temporary, and that their country would be given back to them when the struggle was over.* I can find no grounds for such an assertion. On the contrary, when the Batavian Government afterwards sent a fleet of some nine vessels to retake the colony, in the hope that the burghers would assist them by rising against the English, the burghers refused to move, and the entire force of Dutch ships and men fell into the hands of the English authorities at the Cape without any bloodshed. The fact was, the immense benefits flowing from the change of Government were apparent to the Dutch burghers from the beginning. Their country was never "taken from them;" it was really now given to them as colonists for the first time under the law of England, and it became theirs in a sense in which it never was theirs before. So much for the South African side of the final settlement by which the Cape became an English colony, and the general satisfaction attending it in the colony itself. One word with reference to the European aspect of the question. The possession of the Cape was, and is, a question of European politics. At the Congress of Vienna a final arrangement was made by which certain other Dutch colonial possessions, as well as the European supremacy at the Cape, were handed over to England by Holland, in return for the sum of £6,000,000 sterling. This transaction was little known at the Cape. It was the European settlement of a question in European politics. It is not true that the "bitter spirits at the Cape resisted this—were called rebels, and were shot and hanged in the usual fashion."* I am at a loss to know on what this assertion is based. There was no such resistance after the first engagement; there were no such feelings of resentment, and there was no hanging connected with this arrangement at all. It is very remarkable that such statements should be persistently put forward, not by our enemies but by our professed friends, in opposition to historical facts which are received as such on all sides in the Cape Colony.

Indeed, I believe I am within the truth when I assert that the Dutch-speaking Cape Colonists have never complained as to their own treatment as subjects of the English Government, except in the one matter of the freeing of their slaves, and the admission of coloured people to civil rights as before the common law. Had there been no coloured people in South Africa, or had England remained a slave-holding Power, there would never have been a breach or a jar between the Cape Colonists and England.

In the early history of the colony, the Dutch, French, and English races already stood side by side on public questions. The struggle for the freedom of the infant colonial press was fought out by Scotchmen for the western province, and by Englishmen for the eastern part of the colony. When the English Government wished to form a penal settlement at the Cape, all the colonists united, held enthusiastic meetings at the Exchange, and the English Government gave way to their united earnestness. It has been repeatedly said that no such gathering took place in Cape Town since the time of the convict agitation, till, in September, 1884, the loyal colonists came together, irrespective of race or colonial parties, to beg the Imperial Government not to desert the country, as some wrong-headed advisers would still urge, but to help them in their peculiar and divided condition, as against the lawlessness which was degrading the colonists and frightening away capital from the country.

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* "Oceana," p. 38.

* "Oceana," p. 38.

But if there was no complaint whatever against the English Government as to its treatment of the colonists themselves, why was there disturbance, and why were some colonists hanged at Slagter's Nek? This affair ought never to be imported into the question of English rule, as such, for the events which led to that local disturbance happened to our officers when carrying out the policy which had been laid down not by the old Dutch Company but by the enlightened officers of the Dutch Republic during the brief interval of their administration. We established district courts in the frontier districts on the lines laid down by Commissary-General De Mist; abuses were taken notice of, and protection to life and property was extended to the then boundary of the colony. In the ordinary discharge of police duty in the previously neglected districts, the colonial officers were fired upon by a border desperado. The fire was returned, and the man was killed. At the burial of this person, his brother, in a state of great excitement, called upon all around to assist him in avenging his brother's death, and from that time this man and his family connexions set themselves to devise plans of retaliation upon the officers of law and order. One of their nefarious schemes was to induce the neighbouring Kaffirs to assist them against Government. Similar incidents have too frequently been known elsewhere, where brigandage has been grappled with and put down by a Central Government. Had the Cape Colony remained in the hands of the Dutch Government, its affairs presided over by such officers as General Janssens and Commissary De Mist, these lawless men must have met the fate which everywhere awaits open defiance of law, order, and settled Government. The English Government has made mistakes in South Africa, and Englishmen may profitably point these out; but the establishing of order was no mistake. Such firmness, along with much patience and forbearance, are absolutely necessary to the upholding of anything deserving the name of Government, and he who elevates bandits into heroes that he may decry his own Government, presents an unpleasant illustration of the old proverb, "It's an ill bird that fouls its own nest."

Let me tell you, in few words, what the much-condemned English Government has accomplished in South Africa. It found a community of Europeans in serfdom to a very selfish and exclusive mercantile company; to those enthralled men it gave freedom and citizenship, and an honourable place in that colonial family of which England is the prolific mother. It found them without trade or colonial industry, except the vineyards of the descendants of the French; having neither wool of sheep nor of Angora goat, till these wool-bearing animals were imported. In social and political life there was taken first one step of advancement, then another, and another—all in the way of widening and deepening their liberty—till, some years ago, they obtained, perhaps prematurely, the entire management of their own affairs within the boundary of their own colony. It has been asserted that the Hottentot races suffered by our setting them free,* and that they have died away under our rule. This is not true, as the statistics of Cape population will show to anyone. The races, which were decreasing when we got the Cape, ceased to decrease; even the abject Bushman was affected by the advent of our English rule. Where one prisoner was taken in the Dutch Company's rule, four Bushmen were shot down, a course which would have led to speedy extermination; under the English rule three prisoners were taken to one Bushman shot.† What we wish to infer from this is, not that an Englishman is more merciful than the Dutch-speaking colonist, but that border quarrels should not be left to the settlement of border men, but be dealt with by a strong Central Government.

Besides the officers and men who, from time to time, were discharged in South Africa by the Dutch East India Company, and who became "burghers," or rather vassals, to the company, there was an important addition made to the European population of the Cape some two hundred years ago. The discharged men of the Dutch Company were not of one nationality; but the addition to which I refer was of over 150 French Protestants—men, women, and children—a small number of that noble generation of Frenchmen whose exile from France impoverished that country in after ages, while it enriched England and other free countries of Europe, and reached even to the distant Cape of Storms in its widening beneficial influence. This was the most important addition to the Cape population which took place during the sway of the Dutch East Indian Company. Under that rule the French refugees found liberty of worship, to a certain extent. The use of the French language was discontinued in public worship, and in documents addressed to Government; and a French traveller visiting the Cape, less than a hundred years after the arrival of the refugees, found only one old man who understood French.

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* Oceana, p. 39.

† Official reports quoted in Mackenzie's "Ten Years North of Orange River," p. 510.

In 1820, the sum of £50,000 was voted by the British Parliament towards the colonisation of what is now known as the Eastern Province of the Cape Colony. Applications for passages from 90,000 persons were sent in, but only 4,000 persons could be accepted. There were several English parties of settlers, under their leaders, who spread themselves over a beautiful and productive country; there was a Scotch party also, which took fast root in the hills and dales of the Bedford district, where its descendents are still to be found. Governor Sir George Grey, who had previous intimate knowledge of both Australia and New Zealand, reported some forty years after concerning these English colonists:—"The British settlers of 1820 have succeeded as well as emigrants have done in any part of the world—better than in very many." But in face of all this, and the fact that at the present day the greater portion of the Grahamstown, Queenstown, King Williamstown, and other Eastern Province districts, are cultivated by English-speaking famers, we have been recently told that the "Boers almost alone were cultivating the soil."*

In 1857, the German Legion which had been engaged in the English service in the Crimean war, was settled on the eastern border of the colony; the British and Colonial Governments bearing the expense of the undertaking. There were over 2,000 men, with a very large proportion of officers, but, unfortunately, the great majority of the men were unmarried, and therefore without the restraints or the motives to action furnished by the family life. Still, these deficiences were met by Sir George Grey as far as he could; and many of the Germans then introduced into the colony have been very successful, while some have risen to posts of distinction.

It is quite true that the anti-progressive Cape farmer of the antiquated type has no friendly feeling towards the "Uitlander," or foreigner. It is just possible that this feeling might be mistaken by passing visitor or traveller for an antipathy to Englishmen. I am fearless of contradiction from those who have a right to give an opinion, when I assert that there is no antipathy to Englishmen, as such, in the Cape Colony. In explanation of the dislike to foreigners which exists, it must be remembered that, till recently, the education of farmers was so meagre that they could not transact their own affairs intelligently in any matter which involved accurate account keeping. There can be no doubt that the temptation arising out of this fact was, in numerous instances, too great for the travelling trader, or even the village dealer at the store. The colony is full of stories of sharp practices which certain storekeepeers indulged in at the expense of their ignorant customers. These men were not all English, perhaps not even a majority were so, but all could speak English, and all were "Uitlanders." Sometimes farmers would pass through one village to do business in another at a greater distance where they thought they had found an absolutely honest man. The state of education for some time precluded the farmers from contrasting or comparing the commercial morality of their own sons, as business men, with that of the "Uitlanders" of which they complained. But as farmers' sons enter business, the dislike to "Uitlander" storekeepers will certainly break down. Then the dishonesty of the country people, when they found themselves within touch of the many desirable little things contained in a store, was accepted by the dishonest man of business as an excuse for his own more serious misdeeds. No doubt this state of things is to be taken into account, among other reasons, when one considers the want of enterprise and the backward state of the Cape Colony generally. The farmers became discouraged. They might do their best, but they found, when ready to return home, that they still remained indebted in the books at the store. Farmers also complained that in village stores sufficient difference in price was not made between superior and inferior wools. But these are matters which education is changing. Dutch-speaking people are now largely engaging in trade; farmers themselves now know more about business, and are able to look after their own interest, while the railway opens up a wider choice as to the houses with which they may deal. And so the old-fashioned hatred of the "foreigner," which it will be seen was not without some reason, is destined to disappear, and is indeed even now very much a matter of the past. The prejudice or ill-feeling was never against Englishmen as such. Indeed, it is well-known that Scotchmen and Englishmen are preferred to other "Uitlanders" or foreigners who, from birth and language, might be supposed to be more likely to find favour in the eyes of the Dutch-speaking colonists. Inter-marriage is of frequent occurrence between colonists of Dutch, French, English, and Scotch extraction. Where both the parents are Protestants, the South African house is in no sense divided against itself; and the Europeans of the future Austral-Africa are likely to be second to none in physical power and in general ability.

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* "Oceana," p. 44.

Before leaving this part of my subject, allow me to say that it is not enough to ask what we have done for our colonists in South Africa. It is also of the utmost importance to point out what the influence and guidance of England have saved South Africa from. We have seen how the colonists have thriven and made remarkable progress. Indeed, when we consider the position in which we found them, perhaps no community has made greater progress than the colonists at the Cape under the Government of England. Then the freed slaves and serfs were never guilty of riot or excess after they got their freedom; they have steadily increased in number, and form to-day a useful labouring population. But the great question remains, "What would have been the result to white and to black—to slave and slaveholder—if Europeans holding the sentiments of the Southern States of the American Union had commenced their operations in the Cape Colony, with the whole continent of Africa to the north of them to work upon?" No doubt, in the course of time, and without the interference of England, a school of thought and of morals would have arisen in South Africa like that of the people of the Northern States of the Union. But when would their voice have been heard? Through what oceans of blood this cursed slave question would probably have led the Europeans in South Africa—through the blood of blacks continually, and through the blood of the whites themselves when the crisis came, and the system met its inevitable doom. There are few who will join the writer whom I have more than once quoted to-night in his views relating to the freeing of her slaves by England. That crowning act of the conscience and intelligence of a people was not only dictated by philanthropy and morality, but it was the soundest and highest policy, as to England, her colonists, and the enslaved peoples. To most thinking men that lesson is unmistakably taught by the great American War. President Grant, who was no sentimentalist, declares, in his "Personal Memoirs," that the South was more benefited by defeat than the North by victory:—

> "The South was burdened with an institution abhorrent to all civilised peoples not brought up under it, and one which degraded labour, kept it in ignorance, and enervated the governing class. . . . . The labour of the country was not skilled, nor allowed to become so. The whites could not toil without becoming degraded, and those who did were denominated 'poor white trash.' . . . . The non-slaveholders would have left the country, and the small slaveholder must have sold out to his more fortunate neighbours. Soon the slaves would have outnumbered the masters, and not being in sympathy with them, would have risen in their might and exterminated them. The war was expensive to the south as well as to the North, both in blood and treasure; but it was worth all it cost."*

It is true the ostensible cause of the war on the part of the Southern States was the claimed right to separate; on the part of the North the cause was the inviolable union of the States. But why did the South wish to separate? That they might plant their peculiar institutions in new territories—exactly the same reason as that which induced some of our South African colonists to separate from the Cape Colony, and "trek" into the regions to the north. If, therefore, brother has not shot down brother in South Africa, if father has not found himself opposing son in mortal conflict, as in America, by whose management has the apple of strife been removed from the scene? By the wise forethought and the disinterested policy of England. The freeing of the slaves, the determination to treat men of all races as citizens before the common law, has been precious seed sown in South Africa by the conscience and genius of England, and is destined to bear fruit in the coming generations, and in regions far beyond our control at the time the Emancipation Bill became law. The obligations of all races throughout South

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* *Century Magazine*, November, 1885.

Africa to the Power that has thus befriended all will appear more and more as the lapse of time helps us to understand the true bearing and proportion of things.

BECHUANALAND.

We hasten northward now, by post-cart or other conveyance, across the Vaal River, and through the frontier town of Barkley West, which was Sir Charles Warren's base during part of the time the expedition was in Bechuanaland. Another hundred miles, and we are in Bechuanaland itself.

The term Bechuanaland is of recent origin, and is used loosely to describe the country inhabited by the Bechuana tribes. The most southerly tribe is that of the Batlaping, whose territory borders on the Cape Colony; the most northerly the Bamangwato, the larger division of which tribe lives at Shoshong, under the chief Khame, but occupies the country northwards to the Zambesi; while the smaller division of Bamangwato lives at Lake Nghabe (Ngami), under the chief Moremi, and occupies the country lying to the north and north-west of that lake. The Bechuanaland of the Bechuanas is thus bounded by the Cape Colony on the south, by the Zambesi on the north, by the Transvaal and the Matebele on the east, and by the Namaqua and Damara tribes on the west. The Bechuanaland of the Crown Colony is bounded on the south and east as given above, but on the north and west by the Molopo River. The Bechuanaland of the enlarged Protectorate extends westward to the twentieth degree of longitude, and northward to the twenty-second degree of latitude. The extent of the Protectorate proclaimed by Her Majesty's Government is given by Sir Charles Warren as 170,000 square miles; the Protectorate is thus larger than the Transvaal. Sir Charles calculated that, after all native wants had been satisfied, there would be some 70,000 square miles without occupants.

The name Bechuana is a word used at an early period by white men to denote the tribes of Batlaping and Barolong, with which they came first into contact. None of these people use this word of themselves, or of one another; nevertheless, they accept of it as the white man's name for them, and now begin to use it themselves. In the same way the names Matebele and Basuto were originally terms of reproach, but are now accepted as proper names by those who are addressed by them.

The Bechuanas belong to the large Bantu family of people. Comparative philology con-connects them closely with the South Sea Islanders, and disconnects them from the Hottentots, Korannas, and Bushmen, who are their neighbours in South Africa. All Bechuanas point to the south-east as the direction from which they came to Bechuanaland. The Makalaka also point to the same direction. This probably refers to the fact that these tribes, at some comparatively recent time, occupied countries lying to the south-east, from which they were driven by the more powerful tribes now residing in these regions. Besides Bechuanas belonging to recognised tribes, the individual members of which are freemen, we have Bakalahari—people of the Kalahari—who are made up of the remnants of vanquished Bechuana tribes which have fled to the Kalahari as to a place of refuge, and which are owned as vassals by one or other of the Bechuana tribes, to which they pay tribute in the shape of skins or other produce of the chase, or render pesonal service in the garden or cattle station. A certain vassal tribe in the Batlaping district is called Balala, another Basaomaka; and were inquiry carried into the Kalahari itself, it would probably be found that under the general name of Bakalahari many tribes are now included which have a past tribal history as well as a tribal name, and which once, as tribes, knew better days. Besides these people the traveller in North Bechuanaland meets with Makoba, on the Zouga and Tamalakan Rivers, and Mashepetlane and other "river" people on the Zambezi. These people never leave the rivers. They possess boats and catch fish, which they eat; whereas eating fish is an abomination to Bechuanas. The Makoba say they came from the north-west. They are held in vassalage by the Bechuanas.

The Makalaka are found at Shoshong as refugees, their own country having been to the east and north-east of that place. They have been almost entirely destroyed as a people by the Matebele. They are much better farmers than the Bechuanas, and trust more to their gardens and less to the chase. They are closely allied by language and customs to the Mashona, whose country lies to the east and north-east of Matebele land, and who have also suffered very much by the constantly recurring wars of the Matebele.

The Bushmen of Bechuanaland are taller than those of the Cape Colony. I was informed by the Bamangwato that they knew of two families of Bushmen whose languages were different. Then there are the Madenassana Bushmen, living not far from the Matebele, whose physical appearance is very commanding, and who, although called Bushmen, may turn out to be a remnant of some Koranna tribe, as the people of the Kalahari are remnants of Bechuana tribes. The Bushmen in Bechuanaland in the present day are following their masters' lead in the ways of civilisation. They are employed as herds and wagon servants in South Bechuanaland, and on our recent journey to Shoshong we found, on entering Khame's country, that that chief had entrusted a flock of goats to the Bushmen who were living at Mamabula. In the heart of the Kalahari the vassals have herds of cattle and flocks of sheep and goats of their own, while they herd also the flocks of their master. Thus in Bechuanaland we have no warlike system of polity to contend with on the one hand, nor have we people hopelessly degraded or opposed to change on the other.

It is about eighty years since Europeans first came into Bechuanaland. The first rude trade has almost entirely disappeared from South Bechuanaland; it is still supplied with some skins and feathers from the Kalahari. Large game were found in abundance in what is now called Griqualand West, within the memory of many who are still living—such game as we did not meet with in our recent journey to Shoshong, and as we might not have met with in hundreds of miles to the north of that town. In times of peace, however, the traders of Shoshong still have large quantities of ivory and ostrich feathers, the hunters in many cases crossing the Zambesi or Chobe rivers to get it. Thus the guns, which the natives were so eager to obtain, have enabled them to shoot down the game throughout the whole of the country; and when besides guns—as in the case of Khame's men at Shoshong—the people have horses, then the existence of all large game is a question of a few years, unless, indeed industry is directed in another way, say, to farming.

Bechuanaland is well supplied with grass throughout its whole extent. In South Bechuanaland there are still some forests of acacia trees; but many have been cut down to supply fuel for the steam-engines at work in the Kimberley diamond mines. The "mahatla" or "vaal-bosch" is found in all parts of the country, growing to a tree in the central district. Its prevalence in many parts of South Bechuanaland gives a peculiar appearance to the landscape. The bush is medicinal its wood is highly inflammable even when green, and, therefore, eagerly sought by the traveller in winter, or in a downpour of rain; in winter the bush also affords welcome shelter to stock when grazing. The high-lying country between the Kaap Range and Kuruman consisting mostly of blue limestone, is characterised by a sour grass on which the stock does not thrive, especially cows in milk. In winter they are here attacked by a peculiar bone-disease from which nothing but artificial feeding or entire change of grazing will cure them. But this district has many fine fountains, suited to irrigation, only the soil in many places, and especially on the Kaap Range itself, is very light, and needs heavy manuring. South Bechuanaland, along the Hart River, passing Taung and Stellaland, and reaching the Molopo is a very valuable country both for pastoral and agricultural purposes. The "sheep bush" is found along the Hart River chiefly, while the grasses are sweet and fattening. There are numerous fountains; water is easily obtained in the sand rivers, Setlagole, Maretsanie and Molopo; well-sinking and dam-making would render those portions valuable which are not near a fountain or running stream.

When the traveller reaches Kanye, the scenery improves. Instead of the vast plains of the south he has hill and dale giving many a beautiful view, and suggesting to one after another of our party splendid sites for homesteads. The grasses continue extremely good, while now there is a variety of forest trees, several of which are useful in housebuilding, while others make handsome furniture. The timber of some is proof against the destructive white ant so plentiful in Bechuanaland. The country remains equally desirable along the Notwanie and Limpopo rivers. Following the waggon road, there is to the north of this a belt of less interesting country as to scenery after passing the Matshwapong hills, although the frequent sand-rivers, extensive forests, and invariably good grazing, make the land none the less valuable. At Makobe's Hill a lovely country begins, extending far to the east and north. The views of natural scenery in this district are very remarkable for their beauty. The district due north of Shoshong, which Khame retains for himself and his people, is well wooded and watered, and valuable both for agricultural and pastoral farming. To the north of that again we have extensive salt-pans, some of which still yield good salt; others are grown over with grass. It has been surmised that a tributary of the Zambesi may have, at one time, sent some of its waters in this direction, as the Zouga still does. It is well known that game congregate near such salt-pans for the sake of the salt; and stock of all kinds usually thrive in such a neighbourhood. From these salt-pans, north and north-west, the country is not well-watered, but the pasturage is good everywhere. Both banks of the Zouga river are peopled with Bechuanas and Makoba, a tribe from the north-west. There is first-class grazing on the banks of the river, and large herds of cattle belonging to the natives are now grazing there. In summer, Europeans and natives from other districts are subject to climatic fever in this river district. The most effectual cure is to take the patient away from the river into the high open plain, when little medicine is usually needed to effect a cure, unless, indeed, there has been too long delay, and the malaria has already done its work. Between the Lake River and Shoshong, and westward of Shoshong and of Sechele's, we have a country with deficient surface water, but which is, nevertheless, very valuable. Even now there are numerous small wells in it where Bushmen and Bakhalahari live, the latter with their stock. On the waggon-road between Shoshong and the Lake River, as also on the western road from Shoshong to the Zambesi there are several long reaches without surface water; but I have recently heard of reaches equally long in certain parts of Australia; and no European has thoroughly explored the country away from the waggon-roads with the view of finding water, or likely places for well-sinking. When enterprise and skill have conquered this difficulty, these parts of Bechuanaland will hold their own on account of their very rich grasses. I remember the Bamangwato stock grazing in these regions were always in prime condition. With reference to the Kalahari, which is under Her Majesty's protection, and which has been offered to her Government by the native owners, I shall merely hazard the opinion that in the hands of Englishmen, the Kalahari will turn out to be no desert at all, but a country like many parts of Australia, where you begin operations by sinking wells.

This vast country is only thinly inhabited, taken as a whole, probably not containing 100,000 people from the border of the Cape Colony to the Zambesi. At certain points you have a considerable population; and again you travel for days and never see a human habitation, or, indeed, a human being, except those of your own party. We have already stated how much vacant land there is, according to Sir Charles Warren's calculations. The town of Shoshong is the largest in Bechuanaland, containing, it is said, some 20,000 inhabitants. Besides travelling traders visiting the town, Shoshong is supplied with a considerable number of well-built and well-furnished European stores connected with the Cape Colony and Natal.

It may be desirable here to consider the capabilities of Bechuanaland as a field for emigration. There are commercial or speculative "emigrants" who want so much per cent. per annum on money invested, and there are emigrants who are battling for dear life on some small holding in England or Scotland, and who can barely make ends meet. The hill-country farmer in Scotland is in a region where wheat will not grow at all—only oats or rye; and he may be seen in harvest time hurrying his scarcely ripened crop into the barn, while the snow is falling around him. Or the cottar-fisherman will explain how hard it is—with his plot of land, and fishing besides—to provide clothing and education for himself and his family. I do not think any class of men—or men of any colour—endure such hardships in South Africa. There are portions of Bechuanaland where, in my opinion, a body of some hundreds of agricultural emigrants would, like the Scotch settlers in Baviaan's river some sixty years ago, take root from the first, and make for themselves homes. If they came in considerable numbers, and accompanied by a minister of religion, and possibly a schoolmaster, the children would not be losers by the change, while the church and school house would form that centre in South Africa with which all are familiar in Scotland, and give the people from the first a feeling of home. I would not suggest that such men should be merely agriculturists, but that, like most farmers in South Africa, they should follow both branches of farming. They would begin with some sheep or Angora goats, and a few cows. In the first instance they would have a freehold in the village with right of pasturage, and they would also have their farm itself in the neighbourhood, the size of which would depend upon its locality and capabilities. But with the milk of his stock and the produce of his land in maize, millet, and pumpkins, the farmer and his family would be from the first beyond the reach of want. Irrigation would, of course, enable him to raise wheat, and that would follow in many cases. But as the cold prevented the hill-side farmer from growing wheat in Scotland, so in Bechuanaland, the same man might be placed on a farm where a fountain had first to be opened up, and a dam and water-furrow made, before wheat could be grown; and there are good stock farms where wheat could be grown only by the artificial raising of water by pumping, which means expenditure of money. But what I want to show is that, in any case, the ordinary small tenant-holder would be clearly bettered by the change to Bechuanaland. He has, first, a finer climate. He can raise a better house than he had on that hillside. His stock will thrive and increase, while his maize, millet, and pumpkin field will, at any rate, surpass his patch of oats. In this country he has some plan for paying his rent, as well as for purchasing clothing and groceries. To do this he probably fattens and sells one or two or more head of cattle. And so in Bechuanaland such plans can be made. There is a class in South Africa equally enterprising and persistent with the Scotch pedlars. I refer to the travelling trader, or "smouse," as he is called in South African Dutch. The smouse is everywhere in South Africa. He goes from farm to farm in distant parts of the colony, buying farm produce in exchange for clothing, groceries, and hardware, for the trader's waggon is a magnified edition of the old pedlar's wallet as to variety, and may be said to be in reality a moveable colonial store. These traders have long traversed Bechuanaland, from east to west, from north to south. The Bechuanaland emigrant, supposing no special arrangement had been made for his supplies, could always deal with these traders, who would bring their wares to his neighbourhood, if not to his very door. It is well known that freshly arrived emigrants have little for sale. I do not minimise the difficulties and anxieties of the first years of the emigrant's life, no matter where he is. But with plenty of food, and with thriving stock and well-worked land, the industrious man would be able, by and bye, to feel that his period of anxiety had passed, and he had a full hand, although it might be a rough one—the hand of honest toil, establishing a Christian and contented home in the wilderness.

And now let us turn to our young friend with his capital in his pocket and plenty of pluck and persistence in his constitution. Do you recommend me to go to Bechuanaland for cattle farming? I reply, first, by saying that thousands of Colonial farmers and farmers' sons from Cape Colony and from the Free States have asked for farms in Bechuanaland, many of them after personal inspection of the country. No doubt lung-sickness occasionally prevails in South African stock, as elsewhere when active measures are not taken. The wool can be deteriorated by scab and careless farming. The goats also have their diseases. Buying some stock, along with a fowling-piece and rifle, and giving a large order for cigarettes will not ensure your success as a stock-farmer or wool grower in Bechuanaland, or, indeed, anywhere. That means hard work and close attention, especially at the outset. But if I am asked the difference between Bechuanaland and other fields, I reply that the climate is unequalled; the country is suited for stock farming, and it has the unique advantage of an unlimited supply of native labour, the Bechuanas being unsurpassed as stock-herds, as they are accustomed to it from early childhood. Instead, therefore, of driving away the natives out of a district, it is without doubt our true policy to induce them to remain in it, inasmuch as their labour is so advantageous to the European farmers. Where is my market? Where is Khame's market, and the market of his people, for ivory, feathers, cattle, and grain? Their market is at Shoshong in competing traders' stores. Your market for large transactions would be at Kimberley, and Kimberley agencies. If you can produce what is worth buying, the Diamond Fields will soon hear of it and afford you a market; when the extensive gold fields are opened up to the north the digging population will have to be fed. And Kimberley being within little more than twenty days from England, why should not Bechuanaland meat, "tinned" at Kimberley, compete with Australian? How many miles has the Australian farmer from the interior to carry his produce before he reaches the nearest railway station? Talk about want of water in Bechuanaland, have we not heard of parts of Australia where the farmer has to load up water for his horses or bullocks, so long is the stretch of waterless country? I cannot say to the young capitalist how much per cent. per annum he will make as a farmer in Bechuanaland, but I do say the country is equal to others in which energetic and intelligent farmers do very well indeed, and make admirable homes.

With reference to climatic or malarious fever, it is unknown in South Bechuanaland.

There is the camp fever of the Diamond Fields, which is unknown a few miles out of Kimberley, and occasionally a slightly contagious typhoid fever, of rather a severe kind—which I only met with once in the country, and which came by ascertained infection. It did not attack Europeans, although we were exposed to infection. The malarious fever is not reckoned of any consequence till you reach the Botletle or Zouga River, north-west of Shoshong—or in the Mashona valleys—east of Matebele country. The high-lying country of Matebeleland, and the stretch between that and Shoshong, are not much liable to fever. Certain low-lying parts of the Transvaal have proved fatal to the farmers, especially in very wet summers; but I have not heard of such suffering in any district of Bechuanaland till you reach the northern boundaries of the country. Not only the Zouga or Botletle, but also the banks of the Mababe, the Chobe, and the Zambesi Rivers, are liable to malaria in summer. When Bechuanaland is occupied up to these points the question of malarial fever will be a practical one; not till then.

Surgeon-Major Jazdowski, of Sir Charles Warren's medical staff, who accompanied the General as far as Shoshong, in an interesting report on the geological formation and general appearance of the country (C. 4588, p. 95) says:—

> "Many parts of the country between Molepolole and Shoshong greatly resemble the wilder parts of the North-West and Central Provinces of India—many of the trees, plants, and insects being of similar (sometimes of identical) species. . . . . . The recent epidemics in Bechuanaland (small-pox and measles) appear to have spread from the Cape Colony. Phthisis was nowhere observed, and it would appear that the climate of Northern Bechuanaland might vie with those commonly recommended for consumptive patients."

Mr. George Baden-Powell, M.P., accompanied Sir C. Warren on his visit to the chief Khame, at Shoshong. Having an extensive acquaintance with Australia and other colonies, this gentleman's opinion is of great value. In a report which he drew up, at Sir C. Warren's request, for the information of her Majesty's Government, Mr. Baden Powell remarks:—

> "The country is well suited for English emigrants, and their admission would be some return to the English taxpayer for the expenditure to which he has willingly consented, necessary to enable the Bechuanaland Expeditionary Force to re-establish her Majesty's authority. . . . . . A large portion being land of high value for agricultural and pastoral purposes, and well suited not only for the South African grazing-farm system, but also for the more profitable systems adopted in Australia and elsewhere, where not only stock but crops are well cared for." (C. 4588, p. 74.)

MATEBELELAND AND MASHONALAND.

While Bechuanaland is the valuable and desirable country which I have described it to be, to the east of Shoshong, and north-east, you have a country which is perhaps the most beautiful and most valuable in South Africa. Here, in Mashonaland, the natives grow their own cotton, smelt their own iron-ore, grow rice, as well as other fruits of temperate zones. I have had in my possession cotton blankets made in Mashonaland by African hands, and with an African loom. There is great variety in their style of ornamenting their warlike weapons, and the blacksmith work is very well done. The hills and high lying districts are salubrious. The rich rice plains produce fever in summer. This district is interspersed with old forts, furnaces, and towers, the most westerly of which are to be found in the Bamangwato country, which would seem to have been the limit of the explorations of some enterprising strangers from the east coast, concerning whom we have no record, and no tradition. The buildings are of stone, well hewn, but built without mortar. The buildings were doubtless for the use and defence of men who had come into the country in quest of the gold which is still to be found over such a wide extent of these regions. From the River Mazoe, which flows into the Zambesi, to the Tate, which flows into the Limpopo, the country contains very many quartz reefs, and sand rivers, in which gold is found. I do not wish to overstate the facts of the case. I have not visited Mashonaland; but I have frequently seen its gold in quartz, and in alluvial particles. Its presence is attested by many travellers of undoubted character and ability. The existence of this immense auriferous country was first made known about the same time that diamonds were discovered. The "rush" of men converged on the diamond fields, and afterwards on the gold-fields in the Transvaal. The gold in Mashonaland lies waiting the hand of enterprise and industry.

In these regions the Portugese are said to hold only certain points on the coast, a few miles from which their power is unknown. The Chief Lobingole, the son of Moselekatse, is at the head of the most powerful tribe in these regions. The Matebele have occupied their present country for about forty years. They previously conquered and held what is now the Transvaal for about ten years—the country of Moselekatse being Zululand, or perhaps what is now Natal.

Sir Charles Warren sent a small party, under Major Edwards, to announce her Majesty's Bechuanaland Protectorate to Lobingole. They were well received, only the chief was impatient that affairs should be discussed with small chiefs, such as he professed to regard Khame and Sechele; and said that he waited to be informed what boundary line the English proposed to him as being now his neighbours. We have thus in Lobingole an ally and a good neighbour, if our affairs are managed in those regions with any amount of common sense.

But I am not at all anxious to open up Mashonaland before the time. I am not in haste to explore those old forts and towers, or to enter upon the cultivation of the rich and now largely depopulated districts of that country. It is well that we should know what and where Mashonaland is; but in the meantime we have to do with Bechuanaland, its occupation and its government; and through Bechuanaland with the great question of Austral Africa.

AUSTRAL-AFRICA.

If the Northern States were right in determining at all hazards to maintain inviolate the union of the United States, then was the British Government wrong in South Africa, as acting in behalf of the European race spreading northward there, when it allowed one swarm after another of its subjects to pass out of the colony northward, and assume independence on its borders. This was bad policy in the interests, commercial and otherwise, of the Imperial Government itself; it was unjust and short-sighted towards our colonists in South Africa; it was no kindness, but the opposite towards the communities whose separation secured our sanction; and it has led to endless complications and serious perils in connection with the native races. The crowning act of this short-sightedness was the Sand River Convention, in which precious document our rulers with light heart practically gave up for ourselves and for our loyal colonists all right, title, or portion, in the northward development of Southern Africa. This folly was not repeated either in the Pretoria Convention or in the Convention of London, in both of which the boundaries of the Transvaal were laid down.

Then the responsibility which, by the Aliwal North and Sand River treaties, we sought to impose upon others, we have never been able to divest ourselves of. In their difficulties with the Basutos, the Free State twice asked our interference and assistance, which were granted. The third request was from the Basutos that we should again interfere, to which in like manner we agreed. The President of the Transvaal requested a Commission to settle the western boundary of the Transvaal Republic, and at his desire Governor Keate, of Natal, was nominated arbitrator, should the Commissioners not agree. Thus, in a left-handed, inconsequent, and hazy manner, the English Government was still supreme in the country, and tacitly so recognised even among the separated States. On this side of the water the continuance of the office of High Commissioner satisfied most people, who seemed to think that in some talismanic way the retention of that office met our obligations to the native races on our borders in South Africa.

The serious mistake which had been made in allowing the European population in South Africa to separate and to drift, without one wholesome thought of the future of the people as a whole, or of our own exclusion from the best part of the country, at length occurred to English statesmen. We had fled from responsibility in one form; our flight brought responsibility upon us in another form; we came to realise that we were responsible for a disunited European population in South Africa, and more recently it dawned on us that we were responsible also for a policy which would shut ourselves and our commerce out of the interior of the country.

We are all aware that special steps were taken by her Majesty's Government, under the High Commissionership of Sir Bartle Frere, to repair the error which the English Government had previously made in South Africa, and to re-unite the Europeans in that country. If high character, first-class ability, and indomitable perseverance could have secured success, then was success certain to those who sought out and sent Sir Bartle Frere to South Africa. But all these and other high qualities failed to command success in carrying through the policy with which he was charged. The rejoining of the separate parts of the European community was not a work which could speedily be accomplished. Prejudices were deep-rooted, ignorance was great, genuine mischief-makers were everywhere. In any case the operation, to be a voluntary one, needed time, and it was required that there should be no blundering on the part of subordinates, and unbounded and enthusiastic support from England. Had all these requisites been present, some measure of success might have been secured; as it was, all were conspicuously absent.

But, in my humble opinion, the real cause of the failure lies deeper, and is one which I venture to point out in order that it may be laid to heart in our present circumstances. At the time referred to, we did not seek to obtain and to uphold the position of a General Government for general purposes in South Africa, to which all would have welcomed us. Unfortunately we sought local supremacy within the several States, and thence arose the complaint of irritating interference with local freedom. Now the General Government of the United States is not supreme within each State as to the local affairs of that State. The local State Government is supreme within its own borders as to its own affairs. The conquest of Zululand and Kaffirland, and the annexation of the Transvaal, pointed rather to the unification of South Africa than to its confederation.

It is one thing to enter by a gate or cross over by a stile; it is another thing to try and force your way through a thorn hedge. You will say, "We all agree as to the thorn hedge in South African politics, but where is the gate or the stile?" In a humble way I have been pointing this out for some years in various ways, and will do so once more tonight. I have long seen that there is common ground upon which the Imperial Government, the Colonial Governments, the Governments of the Free States, and the native chiefs and people can meet and co-operate. It is apparent to all peoples in South Africa that the law of European society there is to expand northward. The country is to a great extent unoccupied. Looking to the actual facts of their position, native chiefs intelligently and earnestly ask that the English Government should assume the responsibility of presiding over the occupancy of these wide territories by English and Colonial settlers. They make this request in self-defence. They regard our government as the Supreme Government of the white men in South Africa. They demand protection from lawlessness, and assistance in administering law and order. Now, the holder of these unoccupied regions, whoever he is, will be the supreme power in South Africa. The open gate, then, to supremacy in South Africa, uncontested and incontestable, is through such treaties as we were offered and refused in Bechuanaland in 1878, but which have been recently drawn up and concluded in Bechuanaland, and which may be extended when desired in adjacent regions. It needs only a glance at the map to receive the geographical assurance of the truth of my doctrine. But other common-sense proofs will occur. By adopting the policy which I advocate, instead of having to run after any local government in South Africa, asking it for this and for that, we might have every government there knocking at the door of our General Government, and making requests of us. No doubt they would come to us because they wanted something from us; but it would be our happiness in most cases to have that to bestow which they came to ask. The holder of the unoccupied land is the master of the situation; all will be his friends, and all will be quite willing to pay something for his good offices.

Then I preach the old doctrine once more which I taught before in this country, and which was more recently cheered to the echo in the Cape Colony, that, under a General Government, there was abundant material in South Africa itself for the performance of all the fighting that may be required in the defence of peace and order. The forces of order are strong enough, but at present are hopelessly divided, as was shown in the unchecked Bechuanaland disturbances. But that they exist and are active, and sympathise with the right side, was abundantly shown in the alacrity with which they volunteered under Sir Charles Warren.

To carry this out successfully some changes would be requisite in our methods in South Africa. Any beginning of a General Government could not be conveniently connected with a local government. No general trust throughout South Africa would be extended to an officer as High Commissioner who is also governor of a colony. The advantage of carrying with us the approval and support of colonists is undoubted; but this would be best secured by an offieer outside their local party strifes. He would not contemplate anything which would be to the disadvantage of the colony; but all our doings would continue to be a bone of contention and of party debate if the offices are joined as at present. The history of Bechuanaland administration is an illustration of this. If her Majesty's Government were to call together from both parties in the House of Commons a committee to consider our future action in South Africa, that course would strengthen their own hands, while it would evoke confidence both in this country and in South Africa.

The one fear of the true friends of South Africa, especially those living in South Africa, is that the English Government will not persevere in the work which has been begun in Bechuanaland. The leaders of both political parties at the Cape, the newspaper press throughout the colony, the late Special Commissioner of Bechuanaland (Sir Charles Warren), the present High Commissioner, in his utterances in England two years ago, when the present course was embarked on, all agree as to the importance of our holding Bechuanaland, and presiding over the settlement of Europeans who may take up their abode in that country.

In this connection I venture to express the opinion that the present government of Bechuanaland is not a satisfactory one, and there is a great likelihood that unless a change takes place it will not lead to satisfactory results. I am not attacking men, I am criticising a mode of government. If a man is administrator of a colony, can he also be president of a land court settling the initial difficulties of the land question in that colony? Can he also be his own legal adviser, and the supreme legal adviser of others, and yet be a judge of final reference? I may be misinformed, but I understand that Judge Shippard, an able and upright judge, has complex and impossible duties of this kind forced on him. Sir Charles Warren submitted a scheme for the government of the whole of Bechuanaland which would have been infinitely more satisfactory, and in a year or two more likely to pay its way than the present system is. A similar scheme drawn up by Mr. Baden-Powell is also before the Government. If we courted failure in order that we might retreat, heedless of consequences, the present system of government seems admirably adapted to our purposes. If we intelligently seek to discharge the high duties in Bechuanaland which are pressed on us by the natives and colonists alike, we shall lose no time in altering our mode of procedure in our newest colony—giving it, and the officer at its head, a fair chance, while we secure the peaceful development of both North and South Bechuanaland.

South Africa is not like India, inasmuch as it has immense unoccupied tracts into which it has been satisfactorily shown emigrants can be introduced with the approval of the native chiefs and people. But then, South Africa is not like any other mere colony, inasmuch as the African continent northward must be taken into account, with its numerous inhabitants. As the European cry in America is Westward, so the European cry in South Africa is Northward. Further, our dominions in South Africa are not like other colonies, because they already contain native peoples who have attained to some degree of civilization, and whose rights no European power would ignore. Men are worthy of some consideration—no matter how flat their noses—who lead out fountains, irrigate their own lands and gardens, smelt their own metals, and who in some districts cultivate their own cotton and make their own blankets and shoulder-cloths; who have their own simple modes of government, in which, strange to say, there is the same variety, in a rude fashion, that there is at present among the natives of Europe. The "autocratic" is—or rather was—represented among the Zulus, with every grown-up man a soldier and little else, with little personal property, no public opinion — one man alone supreme. The "limited monarchy" is found among the Bechuanas, Basutos, and Bapedi, where the chiefs must consult their "brothers" or councillors, and where public assemblies of all the men of the tribe are frequently held, both in times of peace and in war. The "patriarchal" or simplest form of government is found amongst the most industrious of all the tribes, the Mashona and the Makalaka, who excel as husbandmen as well as workers in iron and in cotton.

The maxims which guided these schemes of government were suited to the time when there were no white men crowding into the country. While our civilisation is too far ahead of theirs for them at once to imitate, they soon make a gratifying beginning. When we find gardens irrigated, fruit trees planted, and wheat as well as maize under cultivation by these people, no man with any sense of fairness would wish to dispossess such an industrious farmer for no other reason than the colour of his skin. The most industrious men in South Bechuanaland are the most anxious for the establishment of our rule, in the hope that it will protect them in the enjoyment of the fruits of their industry. Chiefs and people have learned enough by recent events to desire that the spread of Europeans should be accompanied by the control of English authority. They do not object to our coming into their country—or rather, the people welcome it; the chiefs no longer object when they see that the current is resistless. But they ask security, they ask protection, they ask to be taught.

A few years ago this request was made by the chiefs and people of South Bechuanaland, and was for the time practically granted. Native law had been weakened; all were willing to be under English law. It was not the decay of the native people; it was merely the passing away of an effete form of power. The offer of these chiefs was of vital importance to us, as representing the Central Government, as it was to those who made it. But never knowing our mind since the fatal time (now over thirty years ago) when we shrank back from doing the bounden duty of the Central European Government in South Africa, the English Government retired from Bechuanaland, leaving no real administrative power behind it. It was certain that in a few months more or less, the country would be the scene of disturbance and bloodshed. This was pointed out to the High Commissioner by those on the spot, but, practically, our power was nowhere in South Africa at that time. All reckless men, all rollicking spirits, all grasping thievish men, began to assemble in the forsaken country. It became their happy hunting ground for years. The Cape Colony resolutely declined to interfere; so did the Governments of the Free States. No one had to do with Bechuanaland; no one would assume the functions of central or general government for the good of the whole community. But so far as England is concerned, her abstention in this instance was really from ignorance of the facts. When the true state of the case came to be known in this country, the English press and public opinion cried shame on the English Government for having practically abdicated its position in South Africa. Where was the High Commissioner? Was there no machinery whatever by which if natives made the request which the Bechuanas had made, that request could be complied with at the expense of the locality, and peace and progress be secured? You know the response of her Majesty's Government, given early in 1884. Without formally committing themselves in so many words, it became evident that the affairs of native territories outside colonies and states had come to be recognised as an Imperial obligation; seeing that there was no General South African Government upon which this responsibility could appropriately be devolved.

But in the meantime other eyes were beholding our action and our want of action in South Africa. If we had been a little longer false to our trust as the head of the Europeans there, and had gone on to allow them to feel forsaken, and to drift and separate (to our own loss and theirs also), we could not any longer have objected to the appearance of another European Power in South Africa. If we allowed disgraceful pillage and rapine on the border of our Colonies and States, which it was notorious was fostered and engaged in by our subjects and by the members of those States, that might be regarded by others as a reason why a strong hand and resolute will should appear on the scene. The sand-banks of Angra Pequena were not mistaken for gold, or for anything else than sand, by Chancellor von Bismarck. But England appeared to be nowhere in South Africa; there was no Power visible except within certain boundaries, and beyond there was hideous disorder. He who reached Bechuanaland and arrested wrong-doing and established law and order, without interfering with one of those Colonies or States, would have done a distinguished action, and one which would have spoken for itself all the world over, and which would have had its own reward in the ownership of countries the inhabitants of which had begged for British administration, and had been refused it. Shut out from Bechuanaland, our commerce and our colonists would have been deprived of that northern outlook which naturally belongs to them.

The Bechuanaland Protectorate, followed by the expedition under Sir Charles Warren, prevented some of the complications to which I refer; and England has regained, perhaps beyond the deserts of her Government, the position which had been all but abdicated. It may with truth be said that our recent policy in South Africa has given sincere pleasure to all educated colonists, without distinction of race. The leader of the expedition evoked the confidence of all classes. To say that war or revenge was ever desired by Sir Charles Warren, or that he worked for war rather than for peace, is a total misrepresentation of fact. It is well known at the Cape who expected war; it is equally well known that a scapegoat was provided by these people on whom the whole blame was to have been laid. But, thank God, the expedition was carried on in Bechuanaland in the spirit in which it had been resolved on by her Majesty's Government. Quietly and firmly the work of pacification was accomplished. Disorder and lawlessness disappeared. While doing this work Englishmen have, of course, gained considerable knowledge of the country. We now know what the possession of Bechuanaland means as to the future of Southern Africa. We have also secured our position there by treaties with the native chiefs. In Bechuanaland we have now a Crown colony and a Protectorate, and also hold in our hands the offer of the Chief Khame of land extending as far as the Zambesi, which is without inhabitants except the bushmen and Khame's hunters and the game. In any other country in the world except England these results of the Bechuanaland Expedition would have been pronounced magnificent, especially if accomplished in circumstances of unexampled difficulty and delicacy. Never did such events take place before in our history in South Africa. We are in possible possession, without a blow, of a region which any colonising Power might covet, which is necessary to our supremacy in South Africa, and the welfare and future confederation of our colonists, and which on our old methods ought to have cost us manifold more in money and in human life. It was, therefore, perhaps to be looked for that the official mind, long accustomed to disaster in South Africa, should be somewhat confused, and at a loss to know what to make of success so great and so speedily accomplished. To shift round from expectation of disaster, and the shielding of oneself by providing a scapegoat, to the attitude of thankful praise for unheard of and unexpected success, must take some time. But the policy of her Majesty's Government in defining the borders of the Transvaal in two Conventions, and in embarking in the administration of native territories outside colonies and states, has already borne good fruit. Having put their hands to the plough in this matter of administration in native territories, the English Government must not look back. Responsibility is less in persistence on that line than on any other; and leads by sure steps to Confederation when our responsibility will be lessened.

Without doubt the greatest and happiest result of the Bechuanaland expedition is that it has helped our South African colonists to believe in the British Government once more. I am not speaking as a partisan, but as a truthful man bearing witness to the condition of an important colony, with which I am well acquainted. I assure you that until the Bechuanaland Expedition reached South Africa, distrust and gloom filled the minds of our best colonists, and met you in high quarters where such views were least to be expected or desired. Among Dutch-speaking and English-speaking people there was the same downcast feeling of desertion by England. As I was not afflicted with this distrust myself, I was able to do something in the way of inspiring others with my own invincible confidence in an English Government and in the English people, when well informed. And you know that when reassurance and confidence began to take articulate form in the Cape Colony, it did so with an earnestness reaching to enthusiasm, which showed how moody and depressed the people's minds had been. The appearance of the Expedition in effect began a fresh chapter in our administrative history in South Africa.

When the interest of all the colonists are one and the same, no matter what language they may speak, or from what European race they have sprung, it is not of much consequence to be inquisitive about the relative proportion as to numbers of the Dutch-speaking and the English-speaking colonists of South Africa. But it has been publicly stated by a high authority, and is probably near the truth, that there are nine English-speaking people to eleven Dutch-speaking people in the Cape Colony, while in Natal the two peoples are equally balanced. Thus in parts of South Africa under her Majesty's Government the proportion is as five English to six Dutch. In the Free States, on the other hand, the proportion is as one English-speaking person to six Dutch-speaking people.

Were South Africa at once united, the proportion would be six Dutch-speaking people to three English. As we have said before, where the interests of all are similar—where all are of one religion, such figures are not of so much consequence. Still there they are, and they no doubt have their lesson. I think you will be of opinion that the happy Confederation of South Africa may be looked forward to, and worked for, but will rightly take place at a future time, when all will understand more about it, and when education has brought the various communities even nearer to one another than they are to-day. The occupation of Bechuanaland by orderly Europeans—perhaps the opening up of the mining region in Mashonaland, and the development of Zululand will, in the meantime, happily take place under the auspices of the Central Government. With their own territories clearly defined, and enjoying complete freedom within these boundaries, the inhabitants of the Free States will be able to give their attention to the development of their own possessions; while some of them will no doubt seek and obtain land in Bechuanaland.

After the clear utterances of Sir Thomas Scanlen, two years ago, and the equally strong advice recently given to England by Mr. Upington, the present Premier of the Cape Colony, it is almost certain that at its next sitting the Cape Parliament will see its way to follow these recommendations to the Imperial Government to extend its administration to the Zambesi, by a definite undertaking to co-operate in a work so evidently to the great and special advantage of the Cape Colony, whether Bechuanaland should afterwards be joined to the colony or not.

But in the absence of union and co-operation among the European Governments in South Africa, and as the one great means of leading to that co-operation and confederation, England must complete her noble task in South Africa—truly noble, although discharged with unequal step and much misgiving.

Allow me to express the hope that you will now know more of that work than you did before; and wherein we have failed and come short, and how the way to repair the past is still open to us, without interfering or doing what is unwelcome, but rather in performing a work to which we are alike called by colonists and by native chiefs and peoples—the work of presiding over the occupation of the great country to the north of Cape Colony. With many thousand square miles of territory offered to our people in North Bechuanaland, the wants of South Africa may be found to answer to our power to supply it like a glove to a hand. Here we have country-people crowding into our large cities, and living, many of them, in wretchedness and want. There we have a sunny sky, a healthful climate, and a boundless country, where such people by their industry could at once find plenty of food, and in the end, a comfortable home.

The land of North Bechuanaland is open for our emigrants so far as the native chiefs are concerned. Already an Association of highly respectable colonists has been formed for occupying a part of Khame's country. They have approached her Majesty's Government, and asked its sanction and approval to form a settlement within the proclaimed Protectorate. I understand they would also gladly welcome co-operation among young English emigrants who would wish to go out and settle there. It would be their ambition to obtain a block of land where settlers connected with the Association might have their lands together, with a village in the centre, which doubtless would soon have its village church.

We are not speaking of names to-night, but of things; but as we speak of Australasia, we may come to use the term Austral-Africa, to which I have introduced you. In a map its first A would begin at the Cape Peninsula, and its final A would naturally reach to the Zambesi, beyond which we have Central Africa. It will probably be easier to write on our maps now than at any future time—Austral-Africa.

DISCUSSION.

Mr. G. **Baden-Powell**, M.P., thought that all must have listened to the paper with the liveliest satisfaction, though tempered no doubt with a degree of regret that it had not been read in another place on the previous evening before the debate on Bechuanaland, because in that assembly, which should be nameless, there was a great proportion of the members who had in hand the control of the policy in Bechuanaland, which was fully and painfully ignorant of all that concerned it. He hoped that a copy of the paper would be sent to these gentlemen, so that on the next occasion when the subject was under discussion they would know more about it, when perhaps they would be willing to support any English Government that would go to Bechuanaland and protect the natives in their just rights, and assist English emigrants to achieve that prosperity which they could readily attain in a country possessing a fine climate and soil. A wonderful amount of information had been given in the paper about Bechuanaland, but perhaps he might be pardoned for giving a few particulars of Mr. Mackenzie's life in that country. He had the pleasure of being associated with him on Sir Charles Warren's expedition, and spent forty-six days in interviewing the native chiefs, and he found that Mr. Mackenzie was an admirable master in the art of camping out. On one occasion, while having breakfast by the side of a sand river, they were informed by a native that there was a deadly and poisonous snake close to the tents, and upon going to the spot indicated they found the tail of the snake protruding from a hole in the ground. One of the bold soldiers accompanying the party fired at the snake, though of course without effect, whereupon Mr. Mackenzie, in a cool way, put his hand down and seized the snake by the tail, and whipping it out of the hole, sent it flying in the air, and it fell to the ground very much bruised and knocked about. This was merely an incident showing the knowledge which Mr. Mackenzie possessed of the needs of bush life. Passing to the paper, he thought that it possessed a high political value. One hint thrown out in it, namely, that a Committee of both Houses of Parliament should be appointed to consider the affairs of South Africa, was a most sensible and statesman-like proposal, and he would take care to make it known to the authorities, as he thought if there was anything which that colony had suffered from it was the vacillation which had marked the control of South African affairs by the English Government—a vacillation which the appointment of a committee, such as suggested, might do a great deal to put an end to. English taxpayers had no objection to provide money for the promotion of civilisation and justice in South Africa, but if they found a million of money for an expedition to Bechuanaland, they had a right to call upon the Government to see that the money was not thrown away. He had heard some sinister rumours from Bechuanaland as to the introduction of the liquor traffic among the natives, that certain lands had been taken from them, and that they were not being treated as they ought to be, and, therefore, it was all important that those who provided the funds should press upon the Government the necessity of having some return for the money expended. There was just one fault which he wished to find with the paper. Mr. Mackenzie had told them of the good work which had been done on the northern frontier of the Cape Colony, in Bechuanaland, and the land stretching between the Orange river and the Zambesi, but he had not told them that one of the chief agents in that work, more especially of late years, was that single-minded, resolute, and staunch missionary, the Rev. John Mackenzie.

Mr. F. W. CHESSON said that there was one remark which Mr. Mackenzie had made in his wise and statesmanlike paper that had particularly impressed him, and with regard to which he wished to make one or two observations. He referred to Mr. Mackenzie's opinion that "border quarrels should not be left to the settlement of border men, but should be dealt with by a strong Central Government." This remark he thought contained the key to the policy which should be pursued in South Africa. What was wanted there was a steady and continuous policy, which would be unaffected by local factions and prejudices, and which sought to harmonise conflicting interests. He pointed to the recent history of Basutoland as an example of the policy that England should carry out. The audience would remember the disastrous Basuto war, which cost the Cape three or four millions sterling, without yielding to the colony any corresponding advantages whatever. They would also remember that when Basutoland was reduced to a state of anarchy, the country was again placed under the direct government of the Crown. The Colonial-office sent these residents a gallant officer, who, in his character and mode of action, greatly resembled Sir Charles Warren. He referred to Colonel Clarke, who had had much experience of South African warfare, but who went to Basutoland with the determination if possible to pacify that country. No man could have exercised more self-control or more patience; and he now had his reward, for although confusion and disorder for a long time prevailed, the leader of the disaffected party had now welcomed back his magistrate and paid his hut tax. The vile stuff manufactured at the Cape under the name of brandy had been passed into Basutoland in such quantities as to threaten the people with demoralisation and ruin, but the chiefs had lately made up their minds that they would no longer allow it to be sold, but would prohibit its introduction into the country. All this was worthy of England. But if he turned to Zululand, he found there a policy the very reverse of that which the British Government should adopt. They had first divided the country into thirteen small principalities, and then when the chiefs quarrelled among themselves and peace was broken, they had sent back Cetywayo, but had still divided the country into three parts. They had destroyed the military organisation of the Zulus, and blotted them out as a nation, thus making them the prey of the fillibusters who now infested the country. The British Government stood by while a gallant and noble race, who were eminently capable of being civilised, were being ruined. It is true that when St. Lucia Bay threatened to pass into the hands of Germany the Government got alarmed, and succeeded in inducing the Germans to abandon their pretensions, but although they hoisted the British flag at that place, they yet had not interfered to prevent the Boers from appropriating the adjacent territory, and laying out a township. Two evils would certainly arise if something were not done promptly. The Boers had not only taken possession of the Zulu territory, but many of them were compelling the Zulus to work for them without wages. In other words, there was growing up by the side of the free colony of Natal a species of slave republic. If the Zulus were reduced to a state of serfdom, they would seek refuge in Natal—which had already a very large native population—in thousands and tens of thousands; and such a state of things could not be contemplated without grave alarm. Zululand would then prove another illustration of the fact that it is the worst economy on our part to seek to shirk or to evade our national responsibilities instead of boldly confronting them. He heartily supported Mr. Mackenzie's proposal that a joint committee of both Houses of Parliament should be appointed to deal with this question as a thoroughly practical step, and as calculated alike to vindicate the honour of England and to secure peace and security in South Africa.

Mr. MARTIN WOOD thought the debate the previous night in the House of Commons was an example of the variance of opinion which prevailed upon the subject, and he hoped that the reading of the paper would tend to clear up the matter. All would coincide in the opinion that the British Government should exercise its responsibility, and act upon well authenticated information; and though no doubt this would lead to some friction between the Central Government and the Colonial Government, that was a matter which could be arranged with a little management, and the difficulties could be overcome by sound administration and patience. With regard to the political tone of the paper, there was one aspect of it which rather led him to have some misgiving as to its general tendency. He referred more particularly to the strong condemnation of what was known as the Sand River Convention, and in the next place, the eulogistic praise of Sir Bartle Frere's conduct. It must not be forgotten that the two periods were widely distant. Sir George Clerk, who was the author of the Sand River Convention, was a man of sound judgment; but Sir Bartle Frere, who was no doubt a man of great ability, had characteristics entirely opposed to Sir George Clerk, his policy being that of revolution. The course pursued by him was one that was bound to end in disaster, as it did in the case of his onslaught on the Zulu King. No doubt the right way to get access to a country was that which had been pointed out—to go through a gate or over a stile, and not through a quickset hedge, as Sir Bartle Frere had done. Although he could not agree with all Mr. Mackenzie's conclusions, he thought the paper was a most valuable one, as throwing considerable light upon the subject.

Mr. LIGGINS strongly protested against the policy of Sir Bartle Frere being characterised as revolutionary. He thought the African colonists were much indebted to Mr. Mackenzie for his valuable paper, and had it been read the previous evening before another assembly, no doubt it might have done considerable good. The colonies were the soul and life of England, and there was not the slightest harm in the cheque-book going in one hand provided the Bible went in the other. It was by industry and work that the humbler classes attained a position of wealth and comfort. He wished that a map could be issued, in conjunction with the paper, so as to indicate the district referred to by the author.

The CHAIRMAN observed that the object of the Council, in forming the Colonial Section, was to endeavour to obtain practical suggestions for the benefit of the colonies, and to endeavour to give effect to them as much as possible. He felt sure that the meeting must have been gratified not only with the practical nature of the paper, but with the observations of Mr. Powell and Mr. Chesson. Mr. Mackenzie had particularly brought forward the relations between the Dutch and French Presbyterians, Scotch Presbyterians, and English Dissenters, at the Cape, and it was very desirable that the true nature of those relations should be known. There was no national antagonism of race between these classes, but a natural disposition to unite together, and the pulpit of the common place of worship was as often occupied by the Dutch clergyman as by the Scotch minister. It was a curious circumstance that the full power and capabilities of the Dutch were best found where there was this union with English people, as at the Cape. In New York there was a large Dutch element combined with English, but in the East Indies, Java, and the West Indies, the Dutch by themselves were not so successful as colonists. There had been a great union of the population at the Cape, and the moment that the temporary circumstances of irritation were removed, they might look for a still closer union. Intermarriage had tended much to combine the different races, and would have a still more powerful effect in the future. It was simply political questions which divided the people; the Hollanders said, as Mr. Mackenzie did, that it was the want of policy here, one administration upsetting the other, which prevented them from knowing what course would be pursued. This course was complained of most bitterly, and it was to be hoped, therefore, that the appointment of a joint committee would result in the adoption of a settled policy. With regard to the observations which had been made about the policy of Sir Bartle Frere, he thought that it was hardly necessary to vindicate the conduct of that able administrator, who was put to carry out an unsettled policy, and was praised and blamed by statesmen on both sides. Under such circumstances nothing but disaster could be expected. It had been said that the natural drift of population was towards the north, but this had not been caused by the proceedings of Englishmen; the Kaffir race had been extending northwards for some considerable time, and, therefore, they must look in all arrangements of this kind to those natural causes to which Mr. Mackenzie had drawn attention. He was glad to see that the subject of sinking wells in South Africa had been taken up, believing that this was a matter of great importance in colonial administration. There were remarkable cases in Australia, Algeria, Yucatan, and at Iquique. With regard to the history of the Dutch relations to the Cape, he might say that the Cape was never in any sense a Dutch colony, but was intended purely and mainly for the victualling of the Dutch fleet and squadrons proceeding to the East Indies. In conclusion, he proposed a hearty vote of thanks to Mr. Mackenzie for his valuable and interesting paper, which he trusted would have a good effect upon members of both Houses of Parliament.

The motion having been carried unanimously,

Mr. MACKENZIE, in reply, said that in his paper he had striven to avoid discussing "burning questions," though of course one could not refer to the matter to any great extent without mentioning these things. Mr. Martin Wood had referred to the policy of Sir Bartle Frere and Sir George Clerk, but he made a mistake in supposing that the policy carried out by Sir George Clerk at an early date, or that of Sir Bartle Frere at a more recent date, were the policies of those distinguished servants of the Crown. Sir George Clerk went out to pursue a policy which had been resolved upon by the Government of this country, and he was spoken of throughout South Africa with respect, as having done a most unwise thing in a very able way; while the policy which Sir Bartle Frere was sent to carry out was an impossible one, and this ought to be borne in mind. For the purpose of any healthy discussion of the affairs of South Africa they must, however, shake themselves loose from personalities, and try to attain a stable footing for the consideration of the future of that important country.

THIRTEENTH ORDINARY MEETING.

Wednesday, March 3, 1886; Professor W. CAWTHORN UNWIN, M.Inst.C.E., in the chair.

The following candidates were proposed for election as members of the Society:—

Blythe, Herbert, Church, Lancashire.
Brookes, Thomas William, The Grange, Nightingale-lane, S.W.
Brown, William A., Cliff Lodge, Greenock.
Field, George W., 23, Park-street, Park-lane, W.
Peter, Otho Bathurst, Northernhaye, Launceston, Cornwall.
Tate, Edwin, 21, Mincing-lane, E.C.
Thompson, James Elliot, Thornhill-park, Sunderland.

The following candidates were balloted for and duly elected members of the Society:—

Bedford, Duke of, K.G., 81, Eaton-square, S.W.
Fletcher, Frederick W., 56, Hamilton-road, Highbury, N.
Forth, Henry, New Basford, Nottingham.
Knightley, Thomas Edward, 106, Cannon-street, E.C.
Peebles, Alexander, 23, Marlborough-road, St. John's-wood, N.W.
Spray, Henry John, 23, Arlington-square, N.

The paper read was—

CALCULATING MACHINES.

BY C. V. BOYS, A.R.S.M.

Among the philosophical instruments exhibited at the International Inventions Exhibition, so large a proportion might be classed under the heading calculating machines, and these attracted so much attention, that it was suggested that a paper on this subject alone would be suitable at the present time. At the invitation of the Council of the Society of Arts, I have therefore prepared a description of the various calculating machines which were exhibited. But as it seemed that it would not be right to exclude from this paper all account of similar or corresponding machines, because they did not happen to form part of the collection at South Kensington last year, I have attempted to make what I have to say more valuable, by including an account of other machines which serve a similar purpose to those exhibited. In doing so, however, I have of necessity widened the subject to such an extent that in many cases little more than bare mention of a machine is possible.

Of the simple arithmetical processes, counting is the first and most essential; in the same way among calculating machines, apparatus for counting is the essence of all depending on wheel-work. I do not intend to deal with the subject of counting machines, of which a very great number were exhibited, because counting is not calculating. I would, however, point out that there are two types of counting machines, the first a plain train of wheel-work, such as is generally used in gas meters, in which each arbor turns ten times as slowly as the one on its right. Here the wheels cannot fail to act, the record must be true, but this kind is subject to the objection that the numbers on view change gradually, so that it is not always possible to say what figure ought to be read unless the next one to the right be read first, and even then mistakes are sometimes made. They are, of course, unfit for printing a series of numbers. In the other type of counting machine each arbor is normally at rest, and only moves on one figure when the next to the right passes from 9 to 0. If the counting proceeds at as low rate, the mere friction opposing the motion of each wheel may be sufficient to hold it at rest, in which case any wheel can be moved by hand either way unless the next wheel to the right happens to be passing from 9 to 0. At such times only are the wheels locked. If the counting proceed at a high speed, the momentum would carry each counting wheel as liberated a little too far unless a strong click spring, an efficient brake, or some locking contrivance, were applied.

Addition and its converse, subtraction, are, next to counting, the most simple of all arithmetical operations, they are in fact so simple, that machines for adding a series of numbers, though easily made, do not serve any really useful purpose; for it would take, perhaps, longer to set all the numbers in a column of figures on to an adding machine than it would to add them without the machine; moreover, there is the possibility of setting a wrong figure which cannot be discovered afterwards, so that there is not even the recommendation that mistakes are impossible. No adding machines were exhibited at the Inventions Exhibition, that is if we except arithmometers, which in reality are adding machines of great power, or counting machines, which, of course, are only capable of continually adding 1. Adding machines were made more than 200 years ago, but, for the reasons stated, have not come into use. An early one, by Sir Samuel Morland, is exhibited at South Kensington, together with a book on the subject by the same author, dedicated to Charles II. A series of circles divided into 10 parts each, and three others divided into 20, 12, and 4 parts for shillings, pence, and farthings, are arranged on a block, so that when any one completes a turn it shows on an auxiliary circle that one has to be carried to the next circle to the left. Each circle is then moved through as many divisions as represent the number in the corresponding column to be added, a handle and stop being provided for the purpose, and so the total, at any period of the operation, can be read. I am able to show another of Sir Samuel Morland's adding machines belonging to General Babbage. In arithmometers and difference engines the adding is performed in precisely the same way, but the machine, instead of the hand, performs the operation of adding and carrying. In the *Scientific American* of August 29, 1885, there is an account of a recent adding machine invented by the late Mr. W. J. Macnider.

Passing on to the machines for multiplying and dividing, we find a great number. Here the length of the calculation is so great compared with the number of figures required in the setting, that a machine which will quickly perform the operation is well worth using. Of wheel-work multiplying machines two were exhibited at the Inventions Exhibition, one by Tate and the other by Edmondson, but as these machines are developments of much older ones, a few words on their origin may be desirable.

The earliest machine, if it can be so called, for simplifying the operation of multiplication, is due to Napier, the inventor of logarithms, and is known as Napier's bones. These are nothing more than a series of vertical slices from ordinary multiplication tables. When they are arranged so that the top figures are, in order, the figures of the multiplicand, the series of lines which must be added for the product can be read with great facility.

Viscount Mahon, afterwards Earl Stanhope, was the first to make practically useful machines for multiplying and dividing. He made four machines which still exist. I am able, through the kindness of General Babbage, to show two made in 1775 and 1777. He introduced that which is essential in a calculating machine, viz., the possibility of setting one factor so that at each turn of the handle as many teeth shall operate in the place of each digit, as each digit represents. Thus, if 7201 were to be set, then in the units place one tooth only would operate on the first of the set of dials on which the answer is read, and move it forward 1 at each turn. In the second place nothing would happen, in the third two teeth would act, and in the fourth 7. Thus, at every turn, the number 7201 would be added to whatever number happened to be on the machine. When the handle has been turned as many times as corresponds to the last figure of the other factor, say five times, the number set, 7201, has been added five times, or has been multiplied by five; the number which is set, together with the plate-wheels and appendages on which it is set, are then shifted one place to the left, or the recording dials one place to the right, and the handle turned as many times as corresponds with the last figure but one of the multiplier, and so on till the result is complete. In the 1777 machine, the figures are set upon a cylinder which, at a certain point of its revolution, shifts slightly along its axis, and throws out of gear all the teeth upon its surface which were operating upon the recording dials. In the 1775 machine, the stepped reckoner—a series of nine teeth increasing in length by steps from a short one to one nine times as long, a contrivance used in most modern arithmometers—was first employed. In this machine, however, the slides move longitudinally instead of turning in the operation.

In the 1851 Exhibition two instruments were awarded medals, the first by Staffel, a Russian, which has since been lost sight of, and the other by Thomas de Colmar, now extensively used in this country. This machine is so well known that more than a short description of it is unnecessary. The reversing motion of three bevel wheels, the eraser for clearing off all figures from the machine, and the use of quotient holes, which act as counters to show how many times the handle has been turned in each position of the number slides (and on which, therefore, one of the factors in multiplication becomes recorded, instead of being reduced to nothing, as in the Stanhope machine), are, I believe, due to de Colmar. The arrangement of this machine, of which I have a specimen on the table, is easily understood. There are eight (or more or less) parallel axes all in gear with a long shaft turned by bevel gearing by a handle. Each axis turns once for every turn of the handle. There is on each axis a "stepped reckoner," already described. To the left of each of these axes are eight auxiliary axes, carrying sliding spur-wheels, which may be set by thumb-pieces, so as to gear with one, two, three, or any number up to nine of the teeth on the stepped reckoner. Each auxiliary axis carries a pair of bevel wheels set facing one another, and between each of these pairs is a horizontal bevel, gearing with either the front or the back bevel. By moving a handle, all the pairs can be shifted so as to reverse the motion of the horizontal bevels. Each horizontal bevel carries a number disc. The part of the frame carrying the number discs can be raised and slid along so as to bring the middle one of the sixteen number discs over any one of the pairs of bevels. A series of counting wheels show the number of turns of the handle in each position of the moving slide, if the number does not exceed nine. To prevent overshooting, every auxiliary axis is supplied with a locking plate, so that it is suddenly stopped when the stepped reckoner has done its work. So far the machine can be employed for multiplication, or inversely for division, but unless each number disc were made to move on one tooth as soon as the next one to the right completed each turn, the answers given would not be correct. The mechanism for carrying the tens is always the most troublesome to arrange in a calculating machine. This cannot be done during the calculating part of the rotation for obvious reasons. It is necessary, then, for each dial to make a signal when a carriage is necessary. Again, all the carriages cannot be effected at the same time, for if the last only of a series of nines shows that a carriage is due, it only would change to zero if the carriages were effected simultaneously, while it is clear that all should change to zero. It is necessary, therefore, to perform the carriage of each one just before the next to the left. In the Stanhope machines on the table, this result is obtained by an ingenious contrivance which I cannot easily describe. In the de Colmar machine each number disc, when it completes its revolution, presses back a small lever, which pushes a tenth tooth into temporary gear on the reckoner of the next barrel to the left. Moreover, in passing from right to left each barrel lags one tooth behind the last, and can thus carry one if necessary.

Of the two machines exhibited last year, Tate's is, in its general appearance and working, identical with the de Colmar machine, and Edmondson's is but a step removed. As I had an opportunity of examining these machines very closely while the Exhibition was open, and, through the kindness of the inventors, I have lately had one of each and a de Colmar machine in frequent use, perhaps some remarks on the relations between these three machines may be of interest. I hope I shall succeed in treating this rather delicate matter without wounding the feelings of anyone in this room; I am sure those who are most concerned, to whom I am under deep obligations, will give me credit for being impartial. If I should give in any way a false impression, I hope that Mr. Edmondson or Mr. Tate, will remove that impression in the discussion.

I have said that Tate's machine is in appearance identical with the de Colmar machine. This refers to the general design and to the outside. When opened, at once a great difference is apparent, the most important being the substitution of the best English for what can hardly be considered the best foreign work. It is impossible to speak too highly of the beautiful finish, the accuracy of construction, or the excellent materials which are employed in every part. So far, Tate's machine might be nothing more than the French machine better made. There are, however, improvements in detail in the design. In the first place, the erasing mechanism is, in practice, far more convenient than in the French machine. In the place of a long rack which pulls each dial round until, in consequence of an absent tooth, it stops at 0, an operation performed by twisting a milled head against a spring for one set of dials, and another in the same way for the other set, it is merely necessary to jerk a handle one way to erase one set of numbers, and the other way to erase the other set. The dials are brought accurately to zero by a long steel rod, acting on cams, exactly in the same way that the second hand of a stop-watch is set back to sixty seconds. Another improvement, or change as it has been considered, is the removal of the stops, or cams and cam-guards, which prevent the dials and auxiliary arbors from overshooting their mark in obedience to their momentum. These guards, which act much in the same way that the Geneva stop prevents overwinding of a watch, suddenly bring the dials to rest. In place of these, Tate employs a series of springs under which these parts move stiffly. This, at first sight, seems inadequate, in view of the great speed at which the machines are run. I have done my best to try and make one of these overshoot, but without success. I thought it would be interesting to find how far the dial must really move before the spring brings it to rest. I therefore made the following measures (on the C.G.S. system). The moment of inertia of the dial and its attachments is 10·9, and of the secondary axis and wheels 6·7. If we take a working speed of four turns of the handle a second, we shall find that the angular velocity of these parts is in radian measure 16π or 50·4, and therefore the energy of motion is 22,370 units. The springs are adjusted until they resist a force equal to the weight of a kilog. applied to the teeth, which represents a turning moment of 784,800 units. These figures make the greatest possible amount of overshooting to be about $1\frac{1}{2}°$. Now as no error could be introduced unless an angle approaching 18° were reached, it is evident that the factor of safety is fully 10, and that any fears as to the efficiency of this brake are unfounded. The brake has been found an efficient means of checking the motion of heavier things than the wheels of a calculating machine.

Against this brake may be urged the fact that more mechanical work is spent in driving the machine, but this is so slight that it can hardly be urged with propriety. The remaining improvement relates to the method of holding the carrying arm in its working or its idle position. To what extent the old-fashioned double spring is likely to fail I am not in a position to say; I think I may safely say that the simple spring that takes the place of this double spring can never fail.

Edmondson's machine differs from that of de Colmar, first in its general form. It is not a straight but a circular machine. The line of product holes is as it were bent round so as to make a circle of twenty holes. Outside this, at the back, are a series of radial slides for the setting of numbers. Some of the product holes also serve for quotient holes, there being no special row of dials to count the revolution of the handle. The combination of stepped reckoners, of reversing bevels and number wheels, is identical with that in the de Colmar machine, the only apparent difference depending on their radial arrangement. The locking apparatus is more perfect, for at no part of the revolution can any one of the number wheels be ever moved except by the machine, whereas in the de Colmar machine each number wheel, after being stopped, is for a short time free. The number of turns of the handle may or may not be counted at pleasure, and a choice of three positions is given on the circle of holes on which to make this record. This record may be either forwards or backwards, and so the multiplier may either be worked on to the machine, as in the de Colmar or Tate machine, or if it is already on the machine, as the result of a previous operation, it can—by making the counting proceed backwards—be worked off and leave nothing. The same is true of the dividend in division. This is peculiar to Edmondson's machine, and is a certain advance, for it takes as long to set figures on a machine as it does to make the calculation, and such setting introduces the possibility of error on the operator's part.

The eraser is the same in principle as that in the de Colmar machine, but its application is peculiar on account of the circular form. On lifting up the erasing handle, the central disc on which are all the number wheels is raised out of gear; it can then be rotated, and each disc in turn is set to zero. Here, again, is something peculiar to the machine. Any of the numbers may be erased or left as they were at will. I understand from Mr. Tate that Mr. Edmondson was not the first to make a circular machine, but that Hahn, of Stuttgart, made one 77 years ago, and that that form was then discarded. I know nothing of this other machine, nor is there any evidence that the peculiarities of Edmondson's machine—the locking, the possibility of working on or off, the absence of quotient holes and the eraser are not entirely original. I have more than once heard it urged against Edmondson's machines as made (this of course does not refer to the design or invention, but to the manufacture), that it is roughly made. This is true in so far as the surfaces which do nothing are concerned, for the castings in these places have not even been filed smooth. In this respect I think Mr. Edmondson sets an example which instrument makers would do well to follow. If the care and time which are devoted to the finishing of parts which have nothing to do with the working of an instrument were spent instead in more carefully fitting and adjusting the working parts, we who use them would certainly be better off, but then the purchasing public would not be so well satisfied. Instrument makers to whom I have occasionally made this complaint, assure me that they cannot trust their workmen to do any work accurately unless every part is highly finished, for it seems these men cannot understand that what they call an unfinished instrument can be fit for anything but second rate work. Here, surely, is an opportunity for the technical educationist. Edmondson has finished only the working parts, but these are done sufficiently well to work correctly. In the finish of the working parts and in the material, I should say that Tate's machine is not equalled by any. Against the superiority in this respect of Tate's machine must be set the fact that the cost is exactly double. On the other hand, against the increased powers of Edmondson's machine must be set the fact that Tate's machine has a slight advantage over Edmondson's on account of the slope of the surface towards the operator, the straight rows of holes, and the fact that the number slides are nearest the operator, and are parallel, as in the original de Colmar machine.

I think that what I have said is sufficient to show that each machine is in some respects better than the other, and that both are superior to the arithmometers originally made by de Colmar.

Of other calculating machines I have but little to say. A circular machine, by Wiberg, of Sweden, was exhibited in the Exhibition of 1862, together with a difference engine by the same inventor, also with a circular arrangement.

There is another machine, by Grant, of which there is a specimen on the table, in use in the United States, which, in the cylindrical arrangement of the setting and recording discs, might seem to be developed from the 1777 Stanhope machine.

Passing from arithmometers to machines of another class, we come to one highly specialised. It does one thing only, and that it does well. I refer to an entirely novel instrument, invented by Hartmann, for calculating interest. It is certainly surprising that it attracted so little attention, and seems so little known. It consists essentially of tables, calculated by Hartmann with great labour, arranged as follows:—First, there are a pair of corresponding primary tables. The bottom line of the upper one contains the series of values 1d., 2d., 3d., 4d. and so on, the figure in each column being one penny more than in the one to the left. In the line above this are the values 2d., 4d., 6d., 8d., &c., in the next line 3d., 6d., 9d., 1s., &c., and so on for 183 lines. This, then, is a multiplication table in which the unit 1d. is at the bottom left hand corner. In corresponding columns in the table below are the capital sums which, at various rates of interest from 1 to 10 per cent., increasing by eighths, will yield as interest the 1d., 2d., 3d., &c., per day, which is tabulated in the bottom line of the upper table. Thus, if we take any row in the lower table representing any desired rate per cent., and find any sum marked in one of the vertical columns, the amount found in the bottom line of the upper table immediately above this will show the interest per day, the tenth line will show the interest for ten days, and so on for any number of days or any rate per cent. So far, I have described a special multiplication table rather than a machine, and this it would still be, in spite of the mechanical mounting of the tables whereby the required squares can be almost immediately pointed out, if it were not for the graphical table attached. It is evident that the capital sums in the lower table must differ from square to square by considerable amounts, and not only this but the sums tabulated cannot be even amounts if they produce the 1d. a day exactly. The next lowest even amount is written in the table, and by the side a correction. As the sum on which we may require to calculate interest is not likely to be exactly found in the table, means have to be provided to find the interest due to any differences. This is the part of the machine which is specially ingenious. A second or graphical pair of tables is prepared with a horizontal line corresponding to each horizontal line in the two tables already described. Each of these lines is divided into a series of equal parts, such that the number of parts is equal to the difference between any pair of numbers in the primary tables. Thus in the lower part of the graphical table are capital sums, and in the upper part are pence, shillings and pence, or pounds shillings and pence, which are corresponding amounts of interest. This table is mounted on a cylinder, while the first being longer is mounted on a pair of cylinders. Two sliders are provided, one to be set to the rate per cent., and the other to the number of days. To find the interest on any sum the lower slider is set to the rate, the next lower capital amount than that given is set opposite to the pointer. The difference and correction are set opposite the other end of the same pointer on the graphic table. The upper pointer is set against the number of days. On the one side is the interest on the chief amount, and on the other the interest on the difference and correction combined correct to a farthing. The time occupied is less than would be spent in looking over tables in the usual way, or in calculating by a machine. A pair of horizontal lines are specially divided for the calculation of brokerage and commission. I am able to show a complete machine and the tables separately amounted.

I have also an instrument by Detallanté for the calculation of interest. This only calculates at 5 and 6 per cent. Interest at other rates must be found by a simple proportion sum.

Machines for solving equations were represented by only one example, that for cubic equations shown by Mr. Cunynghame. Equation machines may be divided into three classes, those for solving simultaneous equations, those for equations of any order involving one unknown quantity, and those for solving certain forms of differential equation. The first and last class are almost beyond the scope of this paper, I can, therefore, do no more than merely refer to them. The only machines with which I am acquainted are the invention of Sir William Thomson. In his simultaneous equation machine there are as many pivoted pulley frames as there are unknown bodies, and as many pulleys on each as there are pulley frames. The positions depend upon the co-efficients. There are as many cords passing over one pulley on each frame as there are frames. On pulling the cords the frames are inclined in certain directions, and the angles when measured give the value of the unknown quantities. It is worthy of note that the same machine can be employed to recalculate and correct for any slight errors it makes.

Machines for solving differential equations involve the use of integrating machines, a class of machine which, for reasons stated later, I am reluctantly compelled to pass over.

Of machines for solving equations of a high order, involving only one unknown quantity, there are very few. Mr. A. B. Kempe, whose work on linkages is well known, has shown how to apply linkwork to solve these equations. He employs a series of bars hinged on one another, and jointed by linkwork, or otherwise, in such a manner that each one makes the same angle with the one on either side of it, and the same angle that the first makes with the axis of x on which the first hinges. The equation is put through a trigonometrical transformation, and the new coefficients determine the lengths of the bars When the first bar is rotated, the end of the last passes over the axis of y every time that a root is indicated, and the value can be determined by transforming the new equation back to its original form. Mr. Kempe has shown me the simplest solution of a cubic equation by linkage, which is published in the "Messenger of Mathematics," vol. v., as an extract from the "Comptes Rendus" of 1874, due to M. Saint-Loup. This involves the use of only four links, forming one quadrilateral. When this is deformed, the point of intersection of two opposite sides continued passes a certain point, and then the value of a root may be found by measure.

Mr. Kempe has also sent me a paper by Mr. Freeland, published at Philadelphia, where it is shown that this problem may be solved mechanically by an adaptation of Sir William Thomson's simultaneous equation machine, in which the several pulley frames are connected by linkages, to move through angles successively, which are a series of powers of that moved through by the first. An appendix to this paper gives a history of the problem beginning with a geometrical solution adapted for a machine by Clairaut. Reference is next made to what is perhaps the most interesting possible method. Among the innumerable feats of the analytical engine of Charles Babbage was that of deliberately calculating the value y in the expression $y = a + bx + cx^2 +$ &c., as x increases from nothing through small steps for ever. Whenever the value of y became nothing, the machine would ring a bell and stop, so as to call attention to one value of x which it had found to be a root of the equation.

I am not aware that any of the contrivances mentioned are practically convenient or suitable for the solution of equators. Mr. Cunynghame's machine, at any rate, has this merit, that the only thing that it does it does at once and accurately. This one thing is the solution of an equation of the form $x^n + bx + c = 0$. A cubical parabola is drawn upon a large board, and the points marked for which y has certain values as 1, 2, 3, &c., up to 1,000. A protractor divided so that the divisions and numbers engraved are co-tangents is to be applied to the curve, so that the readings on the axis of x and the co-tangent scale are the coefficients of the equation, then the point or points where the straight edge cuts the curve are roots of the equation. Any cubic equation can be solved by the machine, for by Cardan's rule it can be made to want its second term. It is curious that if two of the roots are impossible, by a second application of the protractor, their value (in impossible measure of course) can be found.

There is also a machine for solving equations of any degree, which I designed some ten years ago, of which I have a model. If the machine is to solve an equation of the nth degree $n + 1$ beams are employed. These are each provided with a pair of pans marked + and —. Alternate beams are always opposite one another. Each beam is connected with that in front of it by a sliding joint. Weights equal to the coefficients of the several terms are put into the pans in order, on to the + or — side, according to the sign. Then one set of beams is made to slide along. In certain positions of the slide the first beam leans over to the other side, and may be made to ring a bell. The reading on the slides is then a root of the equation. If there are not more than two impossible roots they also may be found by the machine. This machine and Mr. Cunynghame's are described in this month's "Philosophical Magazine."

Though the tide-predicting machine, invented by Mr. E. Roberts, F.R.A.S., and made by A. Légé and Co., does not do more than draw a curved line, it may certainly be included as a calculating machine, since in only two hours it will find the height not only of high water, but the level at every intermediate time throughout a year for any place for which the constants have been determined, taking into account twenty different tide components, an amount of work which would take an immense time when worked out any other way. It might seem at first that such a machine must be so complicated that it would be impossible to make clear the principle of its action in a short time, but this is not so, as I hope to show. If the tides were due to a single attracting body in the plane of the equator always at the same distance from the earth—say the sun or moon alone—then the tides would be perfectly regular, and would follow an harmonic law. Their motion would be similar to the motion of a pendulum, or as Sir George Airy has expressed it, the rise and fall of the water would be the same as that of a point moving at a uniform rate round a circle, of which the diameter is equal to the total rise of the water. Now, there are two tide-producing bodies, each of which gives rise to its own effect, so the resulting tide is the sum or difference of that due to either body separately. But this is not all. Neither the sun nor the moon remains in the plane of the equator. They journey north and south, nor do their distances remain constant; they approach and recede from the earth. In consequence, the actual height of the water is not to be expressed by any such simple law as already indicated, but, as is well known, it can be represented as the algebraic sum of the heights of a great number of tides of various amplitudes and periods. Supposing these tide components are known for any place, then the machine can be adjusted, and will calculate the resulting tides as I shall now explain. I have a model which shows how a bob tied to a string passing over a pulley carried by a crank, moves up and down harmonically as the crank is turned. The same string passes under a second pulley, and when that is turned the bob again moves harmonically; but the period and excursion depend on the rate of motion and throw of the second crank. If both cranks are turned simultaneously, the bob has a compound motion, which is the algebraic sum of the motions which either crank would have produced. If a third pulley and crank were introduced, the motion would be still more complex, and so on as the number increased. In the machine exhibited by Légé, there are twenty of these cranks, so connected by gearing that these periods have the same ratio as the periods of the twenty most important components of the tides due to the sun and moon. These periods are the same all over the world, and, therefore, this part cannot be altered; but the different components have different values in different localities, and so the pulleys are moved by cranks, of which the throws can be adjusted by micrometer screws. In the first machine, now at the South Kensington Museum, there were only ten of these pulleys, and they were carried directly by the cranks, and so the parts of the chain joining the upper and lower pulleys did not always remain truly vertical. In the new machine with twenty pullies, each is carried by a geometric slide, and thus moves vertically only, while the pin of the crank is allowed to move horizontally in an adjustable steel slide. The bob which hangs from a fine steel wire consists of an ink bottle moving in a vertical geometric slide, carrying a pen which draws the required curve on a travelling band of paper. Mr. Roberts has lent this year's curve for Singapore, a portion of which I have enlarged.

Such a machine requires the constants of any port to be given to it. These constants, depending so much on the accidents of the situation, can only be obtained by calculation from curves previously found for the same place for a year or more by a tide recorder. These calculations even can be made by a machine called an harmonic analyser, invented by Sir William Thomson. A row of eleven of Prof. James Thomson's integrators are connected as follows:—The y of each instrument is made to follow the curve given by observation. The first merely integrates $y\,dx$, the disc of this having a uniform motion. The discs of the remainder are given a harmonic motion of oscillation depending on the periods of the several components. From the integral shown by each, the numerical value of the corresponding components may be determined.

The same curve is again passed through the machine, but on a drum of half the size, whereby all the discs move twice as often, and thus the values of the first harmonics or octaves of the same components are determined.

It may, perhaps, seem presumptuous in me to make any suggestion on this subject in view of the fact that the harmonic analyser is the work of the greatest mathematical-mechanical genius of the present day. I would, however, suggest that for this special purpose my disc-cylinder integrator is even more fitted than that of Professor James Thomson.

I now pass on to a subject on which I am believed not to be able to speak reasonably. The slide rule is an instrument which makes all who are really familiar with it wonder at the ignorance and apathy of those who are not, that is of nearly the whole community, who neither know what labour they might save by its use, nor care to take the little trouble that would enable them to join the wondering few. I am convinced that if only those who are responsible for the subjects taught in our technical colleges knew how to use this instrument themselves, it would at once become a compulsory subject, and its use would become general in every room and workshop in the land, as I am told it nearly is in Germany and France. The calculating machines already described enable one to obtain answers containing sixteen figures correct to the last figure. This represents a degree of accuracy far beyond anything that is required in ordinary experimental or commercial work. If the data on which the calculation is to be made are liable to a possible error of one per cent., it is useless to insist on what is called perfect accuracy. After the first three or four figures of such a result have been obtained, all subsequent ones have no meaning whatever, they may be ornamental.

Few observations are made in which an error of 1-1000 of the whole may not creep in (I am not speaking here of the most exact scientific work or of some commercial work where far greater accuracy may be obtained); in all such cases, provided the calculation is carried out with a degree of accuracy well exceeding that with which the primary figures are found, the result obtained will be just as good as if long rows of ornamental figures, such as students especially delight in copying from tables of logarithms, had been put on at the end. The question then is what is the quickest and the most convenient way of making those numerous calculations where the term absolute accuracy has no meaning. The very commonest slide rule used by carpenters can be trusted to give results with an accuracy of $\frac{1}{2}$ per cent., while the most accurate instrument of the kind I know, Prof. Fuller's helical rule, gives results trustworthy to a ten thousandth part.

Addition, or subtraction, may be performed by the use of two scales of equal parts which, by way of distinction, may be called A and B. If the zero of one scale A, be placed opposite any number p on B, opposite any other number q on B will be found $p + q$ on A. What I have said about machines for adding applies equally to rules for adding, they are not worth using. There is one exception in the slide rule which was exhibited by Mr. W. Heath, in which the scales, though each of equal parts, are not on the same scale. By the use of this instrument, the correction to be applied to mean solar to convert it into sidereal time, or the reverse, may be found at once, with a possible error of not more than 1-50th second.

What slide rules do is to add quantities but not the numbers which are written upon them. The series of numbers which lie between 1 and 10 are placed at distances proportional not to these numbers but to their logarithms, and these, when added, as is well known, give the logarithm of the product. This is well shown on this large rule, 18 ft. long. The mark numbered 2 is $\frac{301}{1000}$ of the distance between 1 and 10, ·301 being the log. of 2. The same is true of each of the 190 marks between 1 and 10 on the lower line marked D, as is clear from the scale of equal parts adjoining. In this particular instrument, which is an enlarged copy of the ordinary engineer's rule, there are four divided lines, two on the rule and two on the slide, distinguished by the letters A, B, C, and D. The first three lines, A, B, and C, are identical, and of these the two halves are identical. Wherever the slide may be placed, the numbers opposite one another on A and B are in the same proportion, that is, have a common quotient. If the slide is inserted upside down, the numbers opposite one another have a common product. The lower line, D, is on double the scale, and as by doubling the logarithm of a number we find the logarithm of its square, it is evident that when the slide is in its normal position, a table of squares is exhibited. Moreover, however the slide is placed, the squares of any numbers on D are in the same proportion as the numbers opposite them on C; they have a common quotient. If the slide be inverted so that the B line is opposite the D line, they then have a common product. These are all the lines on the rules most usually sold. With these all calculations of ordinary arithmetic may be instantly made, and it makes no difference in the labour if the squares or square roots of any numbers are involved instead of the numbers themselves, for they need only be set upon the proper line. I am not able to show, for want of time, the thousand and one purposes for which these lines may be profitably employed. I will merely give one instance of frequent application. If the length of a square or round bar found on B is set against a certain number on A, opposite the side or diameter on D will be found the weight or volume on C according to the number set on A. Besides the lines mentioned, other lines are sometimes supplied either on the back of the slide or on separate slides. One of one-third of the scale of the D line makes it possible at once to find proportions in which the cubes or square roots of cubes of numbers are involved. A line in which the distance from 1 to 10 (called the radius) of the D line is divided into equal parts enables one to find logarithms directly. One, in which the distances are proportional to the log sines or log tangents of the angles marked, supply at once a table of sines or tangents, or make the results of proportions in which these functions are involved as easily and directly ascertainable as those of simple proportion.

As may be expected, the number of forms in which the slide rule is found is almost indefinite. Any attempt to give a description of every instrument would of necessity fail. There are, however, certain broad principles of construction. In the first place, all rules may be divided into two classes, those in which two lines logarithmically divided slide against one another, and those in which there is only one line, or possibly several independent lines, and a pair of indices, which may be set to measure the angular or linear distance between any pairs of numbers, and be then transferred to any other part of the scale, when another pair, either themselves, or whose squares, cubes, roots, sines, or tangents, as the case may be, will be found in the same proportion. Of the first class, great length, and therefore proportional accuracy, is sometimes obtained by the use of many parallel bars like a gridiron, on each of which part of the scale is engraved. I have, as examples of such rules, one of Professor Everett's in card, one of General Hannyngton's in wood, and one made for Mr. Walford of the same kind, but the largest I have seen. It would make an elegant top for a tea table. There is on the table a rule of this class, where great accuracy is obtained by another method devised by Mr. Beauchamp Tower. In this there are two endless bands, each with a half twist in them, mounted on pulleys side by side. Both sides of the bands are thus available for the scale, and the instrument becomes equivalent in openness of scale to an ordinary straight rule eight times as long. The power of a rule may be extended by the addition of slides working against one another, numbered the same way when division, or opposite ways when multiplication is to be performed. Of rules of this class, I may especially refer to some made by Stanley. Again, instead of scales generally applicable, rules are marked specially for certain trades. As an instance, I would mention one for the iron and steel trades, made by Aston and Mander.

Of plain straight rules there is no limit, and I have not attempted to obtain many. I have, I am glad to say, through the energy of Mr. Fairer, of Leeds, their English agent, a complete set of more than twenty of the rules made by Gravét, of Paris. I am sorry that it is not possible to obtain rules of English make that will compare with these for general convenience and accuracy. It is impossible to describe them all. I have a large model of the ordinary Gravét rule which shows the leading features. The four lines at first seen are the same as those of the engineer's rule, except that the third or C line is the same as the fourth or D line. This is in someways convenient, and in some inconvenient. The back of the slide is divided for sines, tangents, and logarithms, all of which can be read at the back through special openings, without removing the slide. Or the slide may be reversed, and these lines read against the A or D lines for introducing trigonometrical quantities into a proportion without the necessity of first finding their value. A sliding index is provided which adds materially to the power of the instrument. Of all slide rules that I have ever seen, none compare in accuracy, portability, and universality with the ordinary rule of Gravét. I have so far said nothing about circular rules. These are generally of the single line and index class. I have on the table several instruments of this class. There is the most portable rule made, in the form of a watch, by Bouchet, which will do all that the Gravét rule is capable of, but less accurately; two circular rules, by Haas and Hurter, and Professor Fuller; two circular instruments by T. Dixon, one, for simple proportion and logarithms, equivalent to a straight rule 50 ft. long, and the other for trigonometrical work; and the most accurate of all the helical instrument of Professor Fuller.

There is another kind of line, invented first by the late Dr. Roget for finding fractional powers of numbers. A line so divided is called the P line. Here the distances are logarithms of logarithms. A straight and a circular rule of this kind were exhibited by Lieutenant J. H. Thomson, who re-invented the method.

The subject of integrating machines on which, if I had consulted my own inclination, I could have found much to say, I am obliged to pass by, and this I can do with the greater propriety, as Professor Hele Shaw only last year read before the Institute of Civil Engineers a paper on the subject so complete that nothing more need as yet be said. At the Exhibition the most important instruments of this class were the new precision planimeters by Coradi, and Professor Hele Shaw's beautiful spherical integrators. Unfortunately, Amsler's mechanical integrator and planimeter were not on view. Two instruments of mine represented that class of integrators depending on the tangent principle which has been independently discovered by Professor Abdank and myself. Other machines by Rev. F. J. Smith, Mr. Walter Baily, and Messrs. Ashton and Storey, were exhibited. I might add that integrators are the only machines, except certain linkages, which multiply directly and continuously.

It is impossible to conclude a paper on calculating machines without referring shortly to the difference engine of the late Charles Babbage. In the history of calculating machines there seem to be only three great steps, the first was made by the Earl of Stanhope, who put arithmometers into a practicable form; the second by Babbage, when he invented the difference engine; and the third by Babbage, when he invented the analytical engine. The difference engine calculates and prints tables of any kind whatever; once being started it continues to calculate and print without the possibility of error. Unlike the semi-automatic machines, it only requires to be driven by a boy or a donkey-engine.

It depends on this principle; if in a table of any kind, whether of powers of a series of numbers, of sines or tangents, of logarithms, of the value of lives or joint lives, or of anything else whatever, if each number is subtracted from the one above or below it, a table of first differences will be formed; from these a table of second differences, and of third or fourth differences, and so on to any extent, can be formed. Now, in general, after a time it is found that a difference becomes constant, in which case the next one is zero Thus in the table of cubes on the wall, the first differences are 1, 7, 19, &c., the second differences 6, 12, 18, &c., the third differences 6, 6, 6, &c., and the fourth difference is 0. As these columns are obtained by subtraction from the first, it is clear that the first can be formed by addition from the others, and that each of the others can be formed by addition from those to the right. Thus if the first row of figures only are given 0, 1, 6, 6, 0, by addition only a table of cubes may be formed. The diagram on the wall shows how a table of fourth powers is produced by the Schutz difference engine. Any kind of table may be thus formed if only enough differences are introduced. In the difference engine these additions are made mechanically, after each result has been found, type wheels are set automatically, and the result printed on a stereotype mould. I cannot enter into the mechanical details of the Babbage machine. It is well known that the machine was never completed. Small parts have been put together. General Babbage has been good enough to lend one of these pieces, which shows that no work done in these days can excel either in accuracy, excellence of material, finish, or in the substantial character of the work, that which was being put into the Babbage engine. On the wall are drawings of the complete machine, lent by the South Kensington Museum. While this machine was in progress, a printer in Sweden, named Schutz, read a magazine article on the Babbage engine, and he and his son, inspired by this, invented a machine to do exactly the same thing. They put their ideas into metal, and completed a difference engine on a less magnificent scale than that of Babbage. Ultimately a Schutz machine was made for the British Government by Bryan Donkin, and Co., which is now at Somerset House. This machine was employed to calculate and print among other things the well-known life tables of Dr. Farr. The Registrar-General has lent some moulds and casts made by this machine. One of them is part of a table of joint lives, male and female, interest 4 per cent. There is on the table a model by Mr. Edmondson, showing in a general way how the additions are performed in the Schutz machine. As to the details of this and the Babbage machine, and to the methods employed for carrying the tens, it is impossible to enter into them. Though no one would grudge one spark of the honour justly due to a poor foreign printer for the splendid result which he has achieved, it must be a matter of the most profound regret that means were not forthcoming to complete the most magnificent work of the human brain, begun at enormous expense, and that money alone should have prevented the richest country in the world from possessing a monument of its native genius unrivalled in the civilised world.

I am indebted to the following gentlemen and institutions for the loan of the series of instruments as given in the following list. I am also under an especial obligation to Mr. Edmondson, who has enabled me to obtain a large amount of information, and for the very large number of instruments, models, and diagrams which he has lent. Also to Mr. A. B. Kempe for papers on kindred subjects, and to General Babbage for the invaluable instruments which he has enabled me to show you.

THING EXHIBITED.	LENT BY
Model showing principle of adding machine	Mr. Edmondson.
Adding machine, 1666. Sir Samuel Morland	General Babbage.
Old set of Napier's bones..	General Babbage.
Diagram of Napier's bones	Physical Laboratory, South Kensington.
1775 Stanhope machine ..	General Babbage.
1777 Stanhope machine ..	General Babbage.
Thomas de Colmar machine	Mr. Edmondson.
Tate's machine	Messrs. C. & E. Layton.
Separate parts of Tate's machine, showing stepped reckoner and carrying apparatus..............	Messrs. C. & E. Layton.
Edmondson's machine	Mr. Edmondson.
Grant's machine..........	Mr. Theodore Jones.
Hartmann's interest calculating machine. Also the tables used, separately mounted	Hedicke & Co.
Détallantés interest machine	South Kensington Museum.
Model of Saint-Loup's equation solver.	Physical Laboratory, South Kensington.
Cunynghame's machine for cubic equations.	Mr. H. H. Cunynghame.
C. V. Boys' machine for an equation of any degree.	Physical Laboratory, South Kensington.
Model showing action of tide-predicting machine.	Physical Laboratory, South Kensington.
Curve drawn by machine ..	Mr. E. Roberts, F.R.A.S.
Drawing of machine	Messrs. A. Légé & Co.
18 foot slide rule, and other large scales.	Physical Laboratory, South Kensington.
Professor Everett's proportion table..............	Mr. C. V. Boys.
General Hannyngton's rule.	Messrs. Aston and Mander.
Mr. Walford's rule........	Mr. Walford.
Hudson's, Ganga Ram's, and other rules, made by Stanley................	Mr. W. F. Stanley.
Rule for iron and steel	Messrs. Aston and Mander.
Tower's rule	Mr. Beauchamp Tower.
Set of Gravét rules........	Mr. W. Farrer.
Large model Gravét rule ..	Physical Laboratory, South Kensington.
Bonchet calculating circle	Physical Laboratory, South Kensington.
Haas and Hurter circular rule	General Babbage.
Prof. Fuller's circular rule	Mr. F. S. Hunwicke.
Dixon's circular instruments	Prof. Unwin.
Prof. Fuller's helical rule ..	Physical Laboratory, South Kensington.
Dr. Roget's rule for involution	South Kensington Museum.
Part of difference engine ..	General Babbage.
Drawings of Babbage's difference engine	South Kensington Museum.
Model of part of Schutz difference engine	Mr. Edmondson.
Stereotype and moulds made by Schutz difference engine	The Registrar-General.
Diagram showing process of working of Schutz machine	Mr. Edmondson.

DISCUSSION.

Mr. **TATE** said that since he first took up the improvement of the calculating machine, over six years ago, his main object had been to simplify it, and at the same time make it thoroughly durable and accurate. He had sent his machines all over the world, and had never had any complaint with regard to them.

Mr. **BEAUCHAMP TOWER** said he was a very great advocate for the slide rule. His instrument gave results accurate to 1 part in 5,000, which was equivalent to one minute in a week, or one foot in a mile; and when that could be so easily attained, he did not see the necessity for complicated machines, going to a great many places of decimals. The slide rule gave a uniform degree of accuracy, the distance between 90 and 100 being nearly the same as between 9 and 10. If there were an inaccuracy of one per cent. in one part, it would be the same right through the scale.

Mr. **A. J. ELLIS**, F.R.S., said he had used the slide rule to a considerable extent, and the only trouble he found with it was the difficulty of seeing when the lines did coincide; he found that so exceedingly trying to the eyes that he gave it up some years ago, and found that with a table of logarithms he did the work more easily. Still, he had no doubt that, for mechanical purposes, the slide rule would be more easy to manipulate than tables of logarithms, which he had been accustomed to all his life. In calculating machines, in which you had to set the numbers, he had always found the great difficulty was that you were apt to make a mistake in the number; and you could not find it out. You got a wrong result, but did not know where the error arose. He was a bad calculator, and always had to verify his figures, but he liked to have them before him, in preference to using something which he might make a mistake in manipulating. Still, he hoped he was a bad specimen, and that others might use the machines with more confidence. He agreed with Mr. Tower that it was quite enough for most purposes to go to three places of decimals, but you sometimes wanted to go to a fourth to verify the third, and that was not always possible with the slide rule.

Mr. **W. H. MASSEY** had used slide rules since he was a lad, and was pleased to find that some people at South Kensington had at last taken them up. It was a curious coincidence that Mr. Farrer, of Leeds, was now introducing Gravet's rules into the town where he took the first one twenty-five years ago. He had given away dozens of them during the last twenty years, and he was glad that they were now easily procurable, as he should save money thereby. He could not think how an engineer could get on without a slide rule.

Mr. **ACKLAND** said he bought the first arithmometer exhibited by Thomas in 1851, and had used it so much that it was fairly worn out. It gave him great satisfaction, and saved him many hours in calculation. The use of the slide rule ought to be taught in every school, for commercial purposes, calculating interest, &c., and even for checking logarithmic results; for mistakes were often made, not only in the third or fourth decimal, but in the whole numbers. If he did anything by logarithms in a hurry, he always checked it by the slide rule, which frequently discovered an error that might have been unnoticed. He had no experience of any machine but Thomas's, but certainly the improvements introduced by Mr. Tate must add much to the durability, and the indices were so well held by the spring, that it could be operated much more readily than the old Thomas de Colmar machine. It was a credit to Englishmen to turn out a machine so far superior to the French.

Mr. **E. WALFORD** said his attention was drawn to the slide rule a few years ago, and since then he had studied it thoroughly, and he quite agreed that its use ought to be taught in every Board school. Whatever might be a man's trade or profession, he would find it useful, it would save him hours of work; and the more he studied it the more he would discover its capabilities, and the better would he be able to apply it to his special needs. In his own office one of the clerks used to do three quarters of an hour's work every day in working out certain exchange operations, but by means of the slide rule these were now done in ten minutes.

Mr. **STANLEY** said a table of logarithms furnished a very exact method of making calculations, and it was very convenient when you were sitting at a table and had it before you, but the value of the slide rule was that it formed a sort of pocket logarithmic table by which all small matters could be readily calculated. Mechanics in Germany, and some of the best in France, generally carried them, much more so than was the case in England. One point which had not been alluded to was the use which might be made of the slide rule by means of gauge points. If there were a particular multiplier which suited your business, say 112 lbs., you could set the point to that, and you had a whole series of numbers calculated out for you. That occurred in engineering works particularly, but it was also applicable in every trade, and he felt confident that the slide rule only wanted to be better known to be much more employed. On the table there were some special ones by Mr. Hudson, of Glasgow, by means of which all the proportions of a steam-engine, the size of cylinder, length of stroke, and every point of importance could be seen at a glance. Some large firms, such as Kitson's, and Armstrong's, presented all their draftsmen and assistants with one of these rules. It was in these particular applications that the slide rule showed to most advantage, but the ordinary slide rule, especially if fitted with gauge points, might be adapted to any business. With regard to Edmondson's machine, he had had a good many in his hands lately, and having gone through the work very carefully, he could bear testimony that it was perfect in all essential parts, though rough elsewhere. Both this and Mr. Tate's were exceedingly good machines.

Mr. HEDICKE, as a friend of Mr. Hartmann, wished to point out the advantages of his interest calculating machine. The table contained nearly 400,000 numbers, and in order to have them correct they were first drawn out on a very large scale, and then reduced by photography. The great advantage of the machine was its accuracy. If you were calculating interest on a large amount at one-eighth per cent. it was a laborious operation, and might involve adding four, five, or six amounts together, each of which might be slightly inaccurate, and when added together, the error might be appreciable. With this instrument you were sure of accuracy, and saved a great deal of labour as well.

Mr. COFFIN said it was suggested to him at Washington by the International Bureau of Weights and Measures, that the greater use of the slide rule in France than in England might be due to the decimal system. Mr. Boys's opinion on that point would be valuable.

Mr. THOMAS ACKLAND said he was familiar with some of these machines, but others were quite new to him. It was of course impossible for Mr. Boys to deal with all the powers and functions of any one machine, but he was rather surprised that in dealing with the Thomas, Tate, and Edmondson machines, he had not referred to what he considered its greatest power, namely, that if you took any three numbers, call them A, B, and C, you could so arrange the slides as to obtain A + B × C at one operation. That was of great value in calculations involving continuous results, such as actuaries and other mathematicians had to employ in calculating tables. Mr. Peter Gray was the first to point out this power of the machine, and it had been about thirty years before the public before this was discovered. He believed the Edmondson machine had other powers still undiscovered. The working off the result from the circular plate, as distinguished from working it on, with the other two machines was a very remarkable function, and he believed it would be discovered in time that the computation of continuous values in tables was very much facilitated by this remarkable power.

The CHAIRMAN said he had had to his sorrow, rather an exceptional amount of arithmetic to do, and he had probably used all the aids to arithmetic which had been introduced. He was still inclined to think that the one machine which Mr. Boys had not mentioned was the most useful of all, viz., a small table of logarithms. At the same time, no doubt all of these appliances had their use, and many of them he was much dependent on from day to day. Some ten years ago he first saw a Gravét slide rule in Switzerland, and brought one home with him which had been his companion ever since, as there were certain kinds of calculations to which it lent itself very readily; but there were two difficulties which he always found with it; one was that it was always tempting you on to try and be a little more accurate than was easily possible with it, and the other was that there was always a slight difficulty about the numeration. The dodge by which the latter was got over was to think of the characteristics of the logarithms which would express the numbers you were using, but still it was a slight drawback, that you had to spend a little time thinking over what the numeration of the answer was. About twelve years ago he obtained one of the French calculating machines, and had used it occasionally a good deal; recently Mr. Tate had been kind enough to add some of his improvements to it, and he should probably use it for some time to come. It was extremely useful for its particular kind of calculations, and saved an immense deal of trouble; you might have absolute confidence in it, and he had never found occasion to verify the calculations. He had a very good test of that. Some time ago, they used to have an exceedingly heavy task in adding up a complicated table of examination marks to get the total of each candidate, but for seven or eight years he had used this machine to add up the three figure numbers in the table, and, with the sharpest possible critics, a mistake had never been discovered.

Mr. BOYS, in reply, said he had been obliged to omit a great deal for lack of time, but some of the deficiencies which had been mentioned would be found in the printed paper. For instance, he had omitted to mention the sliding index, or cursor, on the Gravet slide rule, by which its powers were enormously increased, and many difficulties in the use of a slide rule eliminated. Dr. Coffin had referred to the greater use of the rule in France as being due to the decimal system, but there were two sides to the question. It was true that you read off at once (if it were a money calculation) the answer in francs and centimes. The French was a rational system, which the English was not, but he might remark that if an English foot rule were divided on the edge into hundredths of a foot, and also into inches divided into eighths, tenths, and twelfths, you could read off at once pence as decimals of a shilling, or other measures decimally in the same way. But the very complexity of the English system rendered the use of the rule more needful for calculation. He had not mentioned the particular point to which Mr. Thomas Ackland had referred, because there were so many other special points in these machines which he was obliged to pass over; but it was quite true that the addition of a number before or after the multiplication could be effected by the arithmometer at once. As Mr. Edmondson was not present, he might perhaps insist still further on the advantage of "working off" figures on that machine. If you had to make a calculation, and the only thing to be done was simply to multiply one number by another, and possibly add a third, the arithmometer, as originally made, was perfect, and was, possibly, preferable to Edmondson's; if, however, you were working out a long fraction in which there might be half a dozen factors in the numerator and in the denominator, as you went on multiplying and dividing, you always had to transfer your result as found to the number slide for the next operation. Whereas in the Edmondson machine you could, as it was worked on, use it as a multiplier and work it off, getting a new answer, which you could again use as a multiplier or which you could divide, always leaving a place for the new result. In reply to the Chairman, he could only say that he did not mention logarithm tables partly because they were not machines, and also because he supposed everybody was familiar with them. As to the slide rule, he had not said all he could against it, but he had certainly not said all he could in its favour, He agreed that one was apt to push the accuracy of the instrument too far, and possibly Gravet's rules—which were by far the best, taking them all round—had this defect, that you might use a lens and strain your eyes in trying to obtain the most accurate readings possible, and the instrument would bear the test, whereas with the majority of English instruments the errors were obvious to the naked eye. He referred to the older instruments; amongst the modern ones many of them were beautifully accurate. The number of figures that should appear in the answer was also a difficulty, especially to beginners. If the answer came out 548, they were not always sure whether that was the real answer or whether it was 5,480,000. But as a matter of fact, there were rules for finding the number of figures in the answer. If you multiplied 2 by 7 there were as many figures in the answer as in the two factors together, whilst 2 × 4 made 8, or one figure less. One rule was, that if the first figure of the product was greater than that of either multiplier, the number of figures in the product was one less than the sum of the number of figures; if less, the number would be equal. There were other rules depending on the manipulation of the instrument, but in practice he had never had occasion to apply these rules. If the calculation was an individual one, it did not take long to run over the figures in your mind, and arrive at a result near enough to guide you; but if you had a number of calculations all on the same pattern, then it was that the slide rule became an instrument of the most enormous utility, you need not trouble about the numbers in the answers; they were sure to steadily increase or diminish, and you only need find out the significant numbers and put in the decimal points at pleasure.

The CHAIRMAN then proposed a vote of thanks to Mr. Boys, which was carried unanimously, and the meeting adjourned.

Miscellaneous.

COLONIAL AND INDIAN EXHIBITION.

A conference between the Lord Mayor and the masters and clerks of the various Livery Companies of the City of London was held at the Mansion House, on Monday, 1st inst., in reference to the forthcoming Colonial and Indian Exhibition. The Lord Mayor presided, and there was a large attendance of the representatives of the Guilds. The proceedings were private, but it may be stated that the following letter from the Prince of Wales was read:—

"Marlborough-house, Pall-mall, S.W.,
"Jan. 12.

"My Lord,—As a member of the Royal Commission for the Colonial and Indian Exhibition to be held in London this year, I have no doubt your Lordship is fully conversant with its general objects, and I need hardly say that my position as Executive President is an assurance of the warm interest I personally take in its anticipated usefulness and desired success.

"The intimate association of very many of the Guilds with the products and resources of our Colonial and Indian Empire, encourages me to ask your Lordship to use your influence with the Livery Companies of London, with the view of inducing those bodies to kindly accord support to the guarantee and donation funds of the Exhibition, which I have every confidence will result in more firmly cementing the ties existing between the mother country and its distant dependencies.

"I have the honour to be, my Lord, your obedient servant,

(Signed) ALBERT EDWARD P.

"To the Right Honourable John Staples, F.S.A.,
"Lord Mayor, Mansion-house, E.C."

The Lord Mayor stated that the Corporation of London had promised £10,000 to the guarantee fund for the expenses of the Exhibition, and the total amount subscribed by the other guarantors—including the Colonial and Indian Governments and private firms—exceeded £200,000. The Master of the Mercers' Company, Mr. Watney, said his Court had guaranteed £1,000, and the Prime Warden of the Goldsmiths' Company, Mr. Stephen Smith, stated that a similar vote would be proposed to his company at their next meeting. The other representatives said they would lay the matter before their respective Courts at the first opportunity.

FOOD SUPPLIES.

Towards the close of last year public attention was directed through the Press to the possibility of a practical increase in the amount of our food supplies by the avoidance of waste. The amount of unused wholesome food daily thrown away from large restaurants and hotels was illustrated at the late Cookery Exhibition, by an average sample of one day's leavings from one establishment. That such wilful waste should occur while there are so many underfed children among the poor was felt to be wrong, but it was also felt that without an efficient organisation the mere expression of opinion that it should be avoided would be without effect. One very simple organisation, arranged by the Baroness Burdett-Coutts, has for three weeks been in operation in Westminster, and is so appreciated that the difficulty has been to supply the demand it has created. It is this. The food that would be wasted is purchased at a nominal cost. The girls of a cooking class are employed, under supervision, to prepare it in a form suitable and attractive for use. The various kinds of scraps and fragments are first sorted, and as they consist of material that has been selected and cooked for restaurant service there is nothing to be thrown away as bad. The "waste," in fact, consist of the remains of 3s. 6d. and 4s. dinners, and is not material that has been discarded on the ground of being not sufficiently good or delicate to be used. With these, pies, puddings, stews, and soups of various kinds are prepared, which are sold between five and seven in the evening in portions priced from a halfpenny upwards. Purchasers have to take their dishes or basins, as the scheme is solely to supply home needs. There is thus no outlay for table requisites and the attendant cost of cleaning. The cooking is done gratuitously, as the girls of the class, while attending to it, are receiving practical instruction with material for which the class is not charged. The cost of fuel is inevitable in all cooking lessons, but this is almost the only expense, so that dishes made of good material, and prepared with due attention to cleanliness and regard to flavour and appearance, are available at a price which bears really no relation to the market value of the meat and vegetables from which they are made. This is one practical solution of the question what to do with waste. Concurrently with this scheme fortnightly lecture demonstrations are being given on how to deal with waste at home.

THE STATE OF INDUSTRY IN PORTUGAL.

The *Jacquard* calls attention to the fact that Portugal, not having any export trade of importance, has had no incentive towards the development of the national industries beyond the point necessitated by the requirements of the middle and lower classes. During the twenty years 1860-1880, there was a gradual increase of wages, but this would seem to have been merely a readjustment, in view of the enhanced cost of living, and the remuneration of the working population is still decidedly lower than is the case in the countries more noted for industrial activity and enterprise.

A measure was before the Legislature some years ago, which was designed for the prohibition of juvenile labour up to the age of twelve, as well as for the supervision of minors as to intellectual training after commencing factory work. Although this proposal did not then become law, it will probably be once more brought forward by the present Minister of Public Works. Technical instruction is now engaging attention, more particularly as to the establishment of weaving schools at Lisbon, Oporto, Guimaras, and Corilha, the last two localities being respectively centres of the linen and woollen industries. The existing Industrial and Commercial Institute and Agricultural Institute (both of Lisbon) are designed rather for the technical education of employers and managers than the training of skilled operatives.

There is, however, no ground for surprise at the absence of such training, as even the elementary education of the working classes is in a condition of great inferiority, scarcely any of the young persons employed being able to read or write. Efforts are being made with a view to the spread of education amongst the working classes, but obstacles of various kinds stand in the way of much-needed reforms in this direction. For instance, the report of the 1881 Industrial Commission states that the professional incapacity of the working classes is to some extent owing to the disinclination of employers to have in their factories ex-pupils of the institutions referred to, on the ground that their pretensions of superiority, and their disposition to place theory before practice, are inadmissible, and calculated to diminish the influence of the proprietors of industrial establishments.

BURMESE PALM PRODUCTS.

A farinaceous substance, resembling sago, is obtained from the pith of several palms. Such are the talipat or *pepeu* (*Corypha umbraculifera*), another species (*C. Gebanga*), the *minho* (*Caryota urens*), the *toungong* (*Arenga saccharifera*), and the *mudaing* (*Cycas rumphii*). The coco-nut or *ong* (*Cocos nucifera*) is cultivated on all parts of the seaboard. The leaves of the talipat or *pepeu* are used as fans, and for writing on, in the latter case being pegged or sewn together, gilded sometimes in patterns on a vermilion ground, and rubbed with petroleum to keep away insects and damp. The leaves of the *minho* afford fibre, and the stem of the *mudaing* exudes a resin used in sores. The juice of the *htan* affords toddy, and, therefore, by boiling down, sugar; and the trunk is applied to many uses. The leaves of the *toungong* yield fibre, the hollowed stem serves for pipes, and the juice drawn at flowering time gives toddy and sugar. These two last-named products are also derived from the juice of the *thenboung* (*Phœnix paludosa*). The *dani* or water palm (*Nipa fruticans*) fulfils many duties; its roots bind the soil of the river banks; the leaf is universally employed in thatching; the juice is converted into toddy, sugar, and vinegar; the fruit is eaten when ripe; the flowers are made into a preserve, and the branches are used as fuel. The prevalent habit of betel chewing renders the areca nut palm (*Areca catechu*) one of the most important of this very useful family.

RUSSIAN SUGAR INDUSTRY.

The United States Consul-General at St. Petersburg, in his recent report, says that the sugar industry in Russia is mostly confined to limited areas in the South-Western, Little Russian, and Prevestland provinces of the Empire, and from the total number of sugar works in successful operation during the year 1883, the distribution was as follows:—In the south-western provinces there were 128 establishments in operation, of which the greater number were in the Government of Kieff, and the remainder in Podolsk. In Little Russia there were 38, in the government of Kharkoff 22, and in the Prevestland provinces 42. In nine other governments 56 establishments were in active operation, of which 14 were in the government of Koursk. The beetroot plantations under cultivation in 1883, in connection with this industry, amounted to 735,000 acres, being an excess of 102,051 acres over the area under cultivation in 1882. Of this total, 302,942 acres belonged to the sugar companies, and 435,058 acres to various planters. During the year 1883, the sugar works consumed 22,473,096 berkovets of beets, the berkovet being equivalent to about 360 English pounds, of which quantity 12,000,000 were utilised in south-western governments, 4,000,000 in the Prevestland provinces, and 6,000,000 in other governments. The results obtained from these operations were as follows:—Of the best sugars, 1,553,295 poods (the pood being equivalent to 36 lbs., avoirdupois); white and moist sugars, 14,422,554 poods; yellow moist sugar, [illegible]9,306 poods, and refined molasses, 1,249 poods. The total number of *employés* engaged in the sugar industry at the manufactories, exclusive of beetroot cultivation, was in 1883, 94,580 persons; of which number 73,334 were male labourers, 13,869 females, and 7,377 children. Consul Swann says that the profits derived from the sugar industry in Russia were not so great in the year 1844 as in 1883, and in the greater number of instances the profits and bonuses at the disposal of the shareholders in the sugar undertakings were much diminished, as the following details relating to the chief Russian sugar factories will show. The dividends of the sugar refinery "Lorodok," for the year 1884, were at the rate of 20 per cent., as compared with 25 per cent. in 1883. The refinery "Jaropowitch" returned 15 per cent. The "Kieff Sugar Refining Company" declared a dividend of 8 per cent., as compared with 10 per cent. in 1883. The "Kalinsky sugar works" gave a dividend of 20 per cent., as compared with profits exceeding 40 per cent. in 1883, and the "Romanoffsky refinery" gave 15 per cent. for the last year's working.

EGYPTIAN FODDER PLANTS.

These are not numerous. Clover, or *bersim* (*Trifolium spp.*) is sown immediately after the fall of the Nile; the first cut, called *râs* or *fâl*, takes place about forty days after the sowing, and just before flowering begins; the second, termed *ribbeh* or *khelfeh*, two months later, the crop being dried for keeping, under the name of *driss*. At the third cutting the plant flowers, and affords seed for next year's sowing. Fenugreek, or *helbeh* (*Trigonella Fœnum græcum*) is very widely grown as an early fodder, being sown as fast as the inundations retire. The Arabs eat the young shoots, which have an odour like melilot; the sprouted grain (grown in water) and the bleached sprouts from it are much esteemed by the Arabs, and a flour made from the grain is mixed in bread. Lucerne, or *bersim hegazi* (*Medicago sativa*) is sometimes grown in artificial pastures, but is not given in the green state to any extent, on account of its tendency to "blow out" the animals. Peas, or *gibbâne* (*Lathyrus spp.*) are sown on the inundated lands, and can be cut for fodder in sixty days, while for the seed, forty days longer are required. The *géraôu* (*Andropogon halepense*) is grown in Upper Egypt for its abundant and excellent fodder.

Notes on Books.

Free Public Libraries, their Organisation, Uses, and Management. By Thomas Greenwood. London: Simpkin, Marshall, and Co. 1886.

The author has collected a large amount of information respecting the working of the Free Libraries' Acts with the object, as expressed in his preface, of helping on the movement for the more general adoption of these Acts. The first Free Library established under William Ewart's Act of 1851, was the one founded at Manchester in 1852, and now the number of places in the three kingdoms where the Acts have been adopted is 133. Mr. Greenwood says that he intended giving a list of towns over 10,000 inhabitants where the Acts have not been adopted, but he found that such a list would form quite a book by itself. The author has given chapters on the chief Free Libraries in the United Kingdom, and also a reference to those in America and Canada, and Australasia. He has also chapters on Museums and Science and Art Classes in connection with Free Libraries, and Free Library Lectures. In an appendix are reprinted the Free Libraries' Acts and Amendments, and information is collected with respect to rules, regulations, and forms for Free Libraries. Copies of requisition for calling meeting to form Library, and resolutions passed at the meeting are added.

THE ARTISTS' MANUAL OF PIGMENTS. By H. C. Standage. London: Crosby, Lockwood & Co. 1886.

This work consists of twelve chapters. The matter contained in the first six, which are devoted to white, green, blue, yellow, red, brown, and black pigments, was first published by the author under the title of "The Artists' Table of Pigments," a work now out of print. The remaining chapters are published for the first time. These are on chemical reactions, colour names and definitions, mixtures of pigments, and artistic qualities of pigments. The last chapter is devoted to the questions set at the South Kensington School of Art Examination in Painting.

SCIENCE IN THE EDUCATION OF THE PEOPLE. By T. Twining. Twickenham: H. and C. Franklin. 1886.

This pamphlet contains a criticism on the treatment which science receives in the Education Code, and suggests a new arrangement of the science curriculum for the Code, alterations in the science instruction at training colleges, and improvements in the Science Directory. The author ends with these words:—"Should the system of scientific instruction of which the general features have been sketched out in these pages, be honoured, in principle, with the approval of the Royal Commission on Elementary Education, it might be so elaborated as to take the children of the people by the hand at an early age, gradually to instil into their growing intellect a sound acquaintance with all that is most essential to know concerning the things of daily life, and coining knowledge into common sense and practical cleverness, effectively to secure success in workshops, and comfort in the home."

THE HISTORIES OF LAUNCESTON AND DUNHEVED, in the County of Cornwall. By Richard Peter and Otho Bathurst Peter. Plymouth: W. Brendon and Son. 1885.

The present borough is styled "Dunheved, otherwise Launceston," but the authors commence their history by pointing out that Dunheved and Launceston were originally distinct places. This volume is chiefly compiled from original documents, which are very extensive, and comprehend most of the reigns from the Conquest downwards, so that the authors "are enabled to relate from contemporaneous documents some local act or event of almost every decade within the last eight hundred years." This volume is fully illustrated.

ELLIS'S IRISH EDUCATION DIRECTORY AND SCHOLASTIC GUIDE FOR 1886. Edited by W. E. Ellis. Dublin: E. Ponsonby.

This annual, which is now in its fifth year of publication, contains information relating to the Irish Universities and Professional Schools, and the Institutions in Ireland for promoting Intermediate Technical and Primary Education, and contains alphabetical lists of Irish colleges and schools.

General Notes.

LONDON SANITARY PROTECTION ASSOCIATION.—The fifth annual meeting of this Association was held last Saturday at the offices of the Association, 1, Adam-street, Adelphi, and it was announced by Mr. Robins, F.R.I.B.A., who took the chair in the unavoidable absence of the Duke of Argyll, that the number of members was now 1,050, having increased by 167 during 1885. In moving the adoption of the report, which was carried unanimously, Mr. Robins said he wished to impress upon the members, and through them upon intending members, that their system was one of practical testing.

PATENT-OFFICE COMMITTEE.—The following memorandum of the Board of Trade is taken from the *Times*:—In consequence of the change of Government, it has become necessary to consider what steps ought to be taken with regard to the Departmental Committee which was appointed by the late President of the Board of Trade (Mr. Stanhope) to inquire into the present constitution and working of the Patent-office. This committee consisted originally of three members, viz., Baron H. de Worms, M.P. (the then Secretary to the Board of Trade), Sir Farrer Herschell (the now Lord Chancellor), and Lord Crawford and Balcarres—and it has been decided that the most expedient course will now be for the Lord Chancellor, in conjunction with the President of the Board of Trade, to appoint a new committee. They have accordingly appointed a new committee, which will be presided over by the Lord Chancellor as chairman, and will consist of the following members:—The Lord Chancellor, Lord Crawford and Balcarres, Baron H. de Worms M.P., Sir B. Samuelson, M.P., Sir R. E. Webster, Q.C., M.P., and Mr. C. T. D. Acland, M.P.

WAGES IN PARIS.—According to the *Annuaire Statisque* the average wages of workmen per day of 10 hours at Paris is:—Excavator, 6 frs.; mason, 8 frs.; mason's labourer, 5 frs.; pavior, 7·50 frs.; pavior's labourer, 5 frs.; joiner, 8 frs.; stonemason, 8·50 frs.; blacksmith, 8.75 frs.; whilst the highest paid workmen are carpenters, who earn as much as 9 frs. per day. A century ago, viz., in 1789, masons only received 2 livres 5 sols. per day; labourers, 1 livre 15 sols.; paviors, 2 livres 10 sols.; paviors' labourers, 1 livre 10 sols.; stonemasons, 2 livres 5 sols.; carpenters, 2 livres, 5 sols.; but no mention is made respecting the length of a working day.

JUVENILE LABOUR IN AUSTRIA.—The *Jacquard* remarks that the evils incidental to juvenile labour in Brünn are difficult to remedy on account of the fact that the young workers are not engaged by the factory owners, but are apprenticed to the weavers themselves. The condition of the working classes in general, in the town referred to, is said to be so insalubrious that the municipal government has had to intervene, with the result that some manufacturers have provided regular dormitories for their workmen, who have hitherto slept (during the relatively short intervals of repose) upon bales of wool in the factories.

ROUMANIAN TEXTILE INDUSTRY.—The steps taken by the Roumanian Government, in 1884, for encouraging the jute manufacturing industry by the free admission of raw material and machinery, have now been followed up by the application of similar facilities to the linen manufacture. The Belgian Consul, at Craïora, has called attention to the favourable opportunity thus afforded for the starting of a new branch of trade. The Government will take all the supplies neccesary for the administration and the army, as well as the medical and educational departments, from the factories of the country itself as soon as they are in a position to furnish what is wanted in linen and hemp goods. The site for a factory would be given free, according to the *Moniteur des fils et Tissus*.

GERMAN CENSUS.—The results of the quinquennial numbering of the population of Germany, which was made on the 1st of December last, have been partly ascertained. In December, 1880, the number of towns with a population exceeding 50,000 was 41, of which 14 had a population exceeding 100,000. Last month the number with over 50,000 inhabitants had increased to 45, of which no less than 21 count more than 100,000 inhabitants. Düsseldorf, Berlin, Magdeburg, Chemnitz, Nürnberg, Hamburg, and Leipsic show an increase during the five years of over 14 per cent., Crefeld over 21 per cent., Kiel, Dortmund, Mannheim, and Carlsruhe over 15 per cent. In Dantsic the population has increased only 5 per cent., while in Memel there has been a decrease of nearly 4½ per cent.

MEETINGS OF THE SOCIETY.

ORDINARY MEETINGS.

Wednesday evenings, at Eight o'clock:—

MARCH 10.—"The Experiments with Lighthouse Illuminants at the South Foreland." By PRICE EDWARDS. Lord RAYLEIGH, Secretary to the Royal Society, will preside.

MARCH 17.—"Eastern Carpets." By VINCENT J. ROBINSON.

MARCH 24.—"Domestic Electric Lighting." By W. H. PREECE, F.R.S.

FOREIGN AND COLONIAL SECTION.

Tuesday evenings, at Eight o'clock:—

MARCH 23.—"Canada and its National Highway." By ALEXANDER BEGG.

APPLIED CHEMISTRY AND PHYSICS SECTION.

Thursday evenings, at Eight o'clock:—

MARCH 11.—"Films and Paper as Substitutes for Glass in Photography." By LEON WARNERKE. Captain W. DE W. ABNEY, F.R.S., will preside.

MARCH 25.—"Certain Methods for the Utilisation of Refuse and Dust Fuels." By WALTER G. MCMILLAN, F.C.S., Demonstrator of Metallurgy, King's College, London.

APRIL 8.—

MAY 13.—"The Scientific Development of the Coal Tar Colour Industry." By Professor R. MELDOLA, F.C.S.

INDIAN SECTION.

Friday evenings, at Eight o'clock:—

MARCH 19.—"Experiences on the Afghan Frontier." By WILLIAM SIMPSON. Col. HENRY YULE, C.B., will preside.

APRIL 2.—"The History of Archæology in India." By JAMES GIBBS, C.S.I., C.I.E., late Member of the Viceroy's Council. Sir GEORGE BIRDWOOD, C.S.I., Member of the Council, will preside.

MAY 7.—"Indian Manufactures from a Practical Point of View." By B. H. BADEN POWELL, C.I.E. The Right Hon. Lord HARRIS will preside.

MAY 21.—"Everyday Life of Indian Women, as revealed in their own sayings." By Capt. RICHARD CARNAC TEMPLE.

The above dates are liable to alteration.

CANTOR LECTURES.

The Fourth Course will be on "Petroleum and its Products." By BOVERTON REDWOOD, F.C.S.

Lecture I.—March 8.—Historical account of Petroleum, and of the Development of the Petroleum Industry. Geographical and geological distribution. Chemistry.

ADDITIONAL LECTURES.

Six Elementary Lectures on "Electricity" will be delivered by Professor GEORGE FORBES, on Saturday afternoons, at Three o'clock:—

Lecture I.—April 3.—Electromotive Force and Potential.

Lecture II.—April 10.—Currents and Resistance.

Lecture III.—May 1.—Magnetism.

Lecture VI.—May 8.—Electro-magnetic Phenomena.

Lecture V.—May 15.—Induction.

Lecture VI.—May 22.—Electrical Measurement.

Tuesday evenings, at Eight o'clock:—

"Japanese Art Work." BY ERNEST HART.

Lecture I.—May 4.—Japanese Metal Work.

Lecture II.—May 11.—Japanese Porcelain and Pottery.

Lecture III.—May 18.—Japanese Picture Books and Drawings.

The rules of admission to these Lectures will be the same as for the Cantor Lectures. Each member has the right of admission for himself and one friend.

Tickets available for all the Society's meetings were supplied to all the members at the commencement of the Session.

MEETINGS FOR THE ENSUING WEEK.

MONDAY, MARCH 8...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. (Cantor Lectures.) Mr. Boverton Redwood, "Petroleum and its Products." (Lecture I.)

Inventors' Institute, 27, Chancery-lane, W.C., 8 p.m. Mr. S. J. Mackie, "An Example of the American Patent-office Examinations."

Surveyors, 12, Great George-street, S.W., 8 p.m. Adjourned discussion on Mr. William Woodward's paper, "London Remodelled."

Geographical, University of London, Burlington-gardens, W., 8½ p.m. Mr. G. A. Farini, "A Journey Through the Kalahari Desert."

Medical, 11, Chandos-street, W., 8½ p.m.

London Institution, Finsbury-circus, E.C., 5 p.m. Rev. H. R. Haweis, "The Anatomy of Musical Notes."

TUESDAY, MARCH 9...Royal Institution, Albemarle-street, W., 3 p.m. Prof. A. Gamgee, "New Function of Circulation." (Lecture I.)

Medical and Chirurgical, 53, Berners-street, Oxford-street, W., 8½ p.m.

Civil Engineers, 25, Great George-street, S.W., 8 p.m. Mr. Dugald Clerk, "The Explosion of Homogeneous Gaseous Mixtures."

Photographic, 5A, Pall-mall East, S.W., 8 p.m.

Anthropological, 4, St. Martin's-place, W.C, 8 p.m. 1. Dr. J. G. Garson, "Exhibition of Instruments for Anthropometric Research." 2. Mr. Arthur J. Evans, "The Flint-Knappers' Art in Albania." 3. Mr. W. H. Penning, "Notes on a few Stone Implements found in South Africa." 4. Mr. Bruce Foote, "Notes on some prehistoric finds in India."

Colonial Institute, St. James's Banqueting-hall, 69, Regent-street, W., 8 p.m. Mr. J. Annan Bryce, "Burma—the latest Addition to the Empire."

WEDNESDAY, MARCH 10...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. Mr. E. Price Edwards, "The Experiments with Lighthouse Illuminants at the South Foreland"

Geological, Burlington-house, W., 8 p.m. 1. Mr. James Thomson, "The Genus *Diphyphyllum*, Lonsdale." 2. Mr. Grenville A. Cole, "The Alteration of Coarsely-Spherulitic Rocks." 3. Mr. Horace B. Woodward, "Account of a Well-sinking made by the Great Western Railway Company at Swindon;" with lists of fossils, by Mr. E. T. Newton.

Microscopical, King's College, W.C, 8 p.m. Mr. A. D. Michael, "Life History of an Acarus, one stage whereof is known as Labidophorustalpæ, and upon an unrecorded species of Disparipes."

Pharmaceutical, 17, Bloomsbury-square, W.C., 8 p.m.

Royal Literary Fund, 10, John-street, Adelphi, W.C., 3 p.m. Annual Meeting.

Royal Society of Literature, 4, St. Martin's-place, W.C., 8 p.m.

Civil and Mechanical Engineers, 7, Westminster-chambers, S.W., 7 p.m. Mr. G. Simonds, "The Erection of Colossal Statues."

THURSDAY, MARCH 11...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. (Chemical and Physical Section.) Mr Leon Warnerke, "Films and Paper as Substitutes for Glass in Photography."

Royal, Burlington-house, W., 4½ p.m.

Antiquaries, Burlington-house, W., 8½ p.m.

London Institution, Finsbury-circus, E.C., 7 p.m. Prof. Ernst Pauer, "The Most Celebrated Composers after Beethoven's time."

Royal Institution, Albemarle-street, W., 8 p.m. Prof. W. Boyd Dawkins, "The Ancient Geography of Britain." (Lecture II.)

Telegraphic Engineers and Electricians, 25, Great George-street, S.W., 8 p.m. Professors W. E. Ayrton and John Perry, (1) "Economy in Electrical Conductors;" (2) "Note on Magnetic Resistance."

Mathematical, 22, Albermarle-street, W., 8 p.m.

FRIDAY, MARCH 12...United Service Institute, Whitehall-yard, 3 p.m. 1. Colonel H. T. Arbuthnot, "The New Military Rifle and its comparison with other Military Rifles, English and Foreign." 2. Major E. G. Armstrong, "The Improved Lee repeating Military Rifle."

Royal Institution, Albemarle-street, W., 8 p.m. Weekly Meeting, 9 p.m. Dr. R. S. Poole, "The Discovery of the Biblical Cities of Egypt."

Astronomical, Burlington-house, W., 3 p.m.

Civil Engineers, 25, Great George-street, S.W., 7½ p.m. (Students' Meeting.) Mr. V. W. Delves-Broughton, "The Process of Coining Gold, as carried on at the Melbourne Branch of Her Majesty's Mint."

Quekett Microscopical Club, University College, W.C., 8 p.m.

Clinical, 53, Berners-street, W., 8½ p.m.

New Shakspere, University College, W.C., 8 p.m. Mr. Sidney L. Lee, "Domestic Tragedy in the Elizabethian Stage."

SATURDAY, MARCH 13...Physical Science Schools, South Kensington, S.W., 3 p.m. 1. Dr. Gladstone, "On the Growth of Filiform Silver." 2. Professor Reinold, "Apparatus for Measuring the Electrical Resistance of Liquids."

Botanic, Inner Circle, Regent's-park, N.W., 3¾ p.m.

Royal Institution, Albemarle-street, W., 3 p.m. Mr. E. B. Poulton, "The Nature and Protective Use of Colour in Caterpillars." (Lecture I.)

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FRIDAY, MARCH 12, 1886.

All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

NOTICES.

CANTOR LECTURES.

On Monday evening, 8th inst., Mr. Boverton Redwood, F.I.C., F.C.S., delivered the first of his course of lectures on "Petroleum and its Products." The lecturer commenced by giving a historical account of petroleum, pointing out that the valuable properties of this substance were undoubtedly well known to Herodotus and other historians who wrote during the five centuries preceding the Christian era, and that the inflammable nature of petroleum gas was probably turned to account by the Persian Fire Worshippers as much as 2,500 years ago. Having traced the progress of the petroleum and shale oil industries from their commencement to the present time, the lecturer proceeded to deal with the geographical and geological distribution of petroleum, and showed that there was hardly a country in which it had not been found, though not always in the same geological formation. Mr. Redwood then referred to a representative series of specimens of petroleum from various parts of the world, in illustration of his statements as to the very variable physical characters of the material, and concluded by explaining the chemical composition of petroleum.

The lectures will be printed in the *Journal* during the summer recess.

ADDITIONAL LECTURES.

The Council have made arrangements for a Course of six Elementary Lectures on "Electricity," which will be delivered by Professor George Forbes, on Saturday afternoons, at Three o'clock. The first two lectures will be given before Easter, on April 3rd and 10th, and the last four after Easter, on May 1st, 8th, 15th, and 22nd.

After Easter another additional Course of lectures will be given by Mr. Ernest Hart, on "Japanese Art Work" (Tuesdays, May 4th, 11th, 18th, at 8 p.m.).

The rules of admission to these lectures will be the same as for the Cantor lectures.

WESTGARTH ESSAYS.

The three essays by W. Woodward, H. H. Bridgman, and J. Corbett, to which the prizes offered by Mr. William Westgarth were awarded by the Society of Arts in 1885, are now published under the title of "Essays on the Street Re-alignment, Re-construction, and Sanitation of Central London, and on the Re-housing of the Poorer Classes." The volume is published by George Bell and Sons at 15s., but copies can be obtained by members of the Society of Arts for 10s. each, on application to the Secretary.

ALBERT MEDAL.

The Council will proceed to consider the award of the Albert Medal for 1886 early in May next, and they therefore invite members of the Society to forward to the Secretary, on or before the 17th of April, the names of such men of high distinction as they may think worthy of this honour. This medal was struck to reward "distinguished merit for promoting Arts, Manufactures, or Commerce," and has been awarded as follows:—

In 1864, to Sir Rowland Hill, K.C.B., F.R.S.

In 1865, to his Imperial Majesty, Napoleon III.

In 1866, to Michael Faraday, D.C.L., F.R.S.

In 1867, to Mr. (afterwards Sir) W. Fothergill Cooke and Professor (afterwards Sir) Charles Wheatstone, F.R.S.

In 1868, to Mr. (now Sir) Joseph Whitworth, LL.D., F.R.S.

In 1869, to Baron Justus von Liebig, Associate of the Institute of France, For. Memb. R.S., Chevalier of the Legion of Honour, &c.

In 1870, to Ferdinand de Lesseps.

In 1871, to Mr. (afterwards Sir) Henry Cole, K.C.B.

In 1872, to Mr. (now Sir) Henry Bessemer, F.R.S.

In 1873, to Michel Eugène Chevreul, For. Memb. R.S., Member of the Institute of France.

In 1874, to Mr. (afterwards Sir) C. W. Siemens, D.C.L., F.R.S.

In 1875, to Michael Chevalier.

In 1876, to Sir George B. Airy, K.C.B., F.R.S., Astronomer Royal.

In 1877, to Jean Baptiste Dumas, For. Memb. R.S., Member of the Institute of France.

In 1878, to Sir Wm. G. Armstrong, C.B., D.C.L., F.R.S.

In 1879, to Sir William Thomson, LL.D., D.C.L., F.R.S.

In 1880, to James Prescott Joule, LL.D., D.C.L., F.R.S.

In 1881, to August Wilhelm Hofmann, M.D., LL.D., F.R.S., Professor of Chemistry in the University of Berlin.

In 1882, to Louis Pasteur, Member of the Institute of France, For. Memb. R.S.

In 1883, to Sir Joseph Dalton Hooker, K C.S.I., C.B., M.D., D.C.L., LL.D., F.R.S.

In 1884, to Captain James Buchanan Eads.

In 1885, to Henry Doulton.

A full list of the services for which the medals were awarded was given in the last number of the *Journal.*

Proceedings of the Society.

APPLIED CHEMISTRY & PHYSICS SECTION.

Thursday, February 25, 1886; Sir HENRY E. ROSCOE, F.R.S., M.P., in the chair.

The paper read was—

PHOTOGRAPHY AND THE SPECTROSCOPE IN THEIR APPLICATIONS TO CHEMICAL ANALYSIS.

By W. N. HARTLEY, F.R.S.,
Royal College of Science, Dublin.

INTRODUCTION.

The spectra of the elements are physical constants of the greatest importance, which, in their relation to methods of chemical analysis, have hitherto been less generally studied than might reasonably have been expected, when we consider that many of the most notable discoveries made by means of analytical processes during the last twenty-five years have been the result of spectroscopic research. The simplicity of the spectra of the alkalies and alkaline earths have rendered them easy of detection with almost any form of instrument, but with other substances the time occupied in making accurate observations, with spectroscopes of the ordinary form, together with the special knowledge required, has delayed the useful applications of spectroscopy to the work of the metallurgist and chemist.

Shortcomings in the construction of instruments in common use have created difficulties and retarded progress in this country, added to which the field of chemical research has been extended rather in the direction of synthesis of organic compounds than in that of the analysis of minerals, and while the former presents many attractions to the enthusiastic student, who feels a peculiar fascination in the actual creation of new substances, the latter entails the exercise of considerable manipulative skill and practical knowledge, with less striking results to show in return for much patient labour. Then, too, the necessary employment of electricity for such observations has served to complicate the processes by which spectra may be accurately studied; but at the present time, the extensive use of storage batteries and dynamo-electric machines for purposes of illumination has afforded greatly increased facilities in obtaining a current for producing spark spectra. In addition, we are in possession of much improved methods of photography; gelatine dry plates of an extremely sensitive character, and excellent for spectroscopic purposes, may be kept in stock and stored for years. These plates are always ready, are developed with extreme simplicity, and do not require the delicate handling necessary with films prepared by the old collodion process. I have used gelatine plates, and found them perfect after keeping for four years, and have experienced no difficulty in developing them after a lapse of a year since their exposure. In the very valuable work of M. Lecocq de Boisbaudran, "Spectres Lumineux," 2 vols., 1874 (Gauthiers-Villars, Paris), we have a treatise on the use of the spectroscope as an indispensable aid in chemical analysis, which, at the present day is unique. It contains a minute description of the method of working which is essential to securing accurate observations. It gives an exact description of about fifty-seven flame and spark spectra, accompanied by plates which have been made from most artistic drawings, and are not only perfect master-pieces of the engraver's art, but faithful representations of spectra, and an accurate record of a series of elaborate investigations made with very simple instruments. By observing bright line spectra continuously for many hours, and particularly spark spectra, the eye sometimes experiences great fatigue, and on this account, as far back as the year 1872, having commenced work on the subject, I arrived at the conclusion that the only method of observation capable of extensive practical application by the chemist would be one in which the spectroscope would be combined with a photographic camera, and the rays to be observed those in the ultra-violet region. This end of the spectrum was the subject of research ten years previously by Professor Stokes (now President of the Royal Society), and the late Dr. W. A. Miller, F.R.S. The apparatus used by Miller for photographing spectra was reconstructed by me, and found to be capable of great improvement; indeed, such improvement was necessary before it could yield results comparable with those obtained in the visible region. The character of the lines was wanting in that delicacy of detail and sharpness we are accustomed to see in the visible spectrum. In 1878 a new instrument and mode of working was designed, and in the following year metallic spectra were photographed by Professor Huntington and myself, the whole of the lines being accurately focussed on one plate, extending from the blue-green rays to those in the extreme ultra-violet, capable of transmission through three feet of air. The researches of M. L. Soret and M. Cornu have resulted in a great improvement in the optical train necessary for the production of such photographs, or for use with a fluorescent eye-piece. The wave-length of the rays which are ordinarily capable of being photographed ranged between 4,800 and 2,000 tenth-metrets.*

A glance at the following Table will show the early date at which spectrum-photography began to attract attention, and the extent of the rays photographed by various experimenters.

PHOTOGRAPHS OF SPECTRA.

By whom Executed.	Date.	Process.	Range and Nature of Spectrum
			Wave-lengths.
E. Becquerel	1842	Daguerreotype and Talbotype..	7,700 to 3,400 solar and stellar.
J. W. Draper	1843	Daguerreotype	4,400 to 3,400 solar.
,, ,, ...	1843	Daguerreotype	8,100 to 6,800 solar.
Herschel	1843	Cyanotype	Not defined. solar.
Miller	1863	Wet collodion	4,500 to 2,400 spark & absorption
Mascart	1867	Wet collodion	3,960 to 2,217 spark.
H. Draper	1874	Wet collodion	5,167 to 3,032 solar.
Cornu	1874	Washed collodion...........	4,500 to 2,948 solar and arc.
Lockyer	1874	Wet collodion	4,500 to 3,900 solar and arc.
H. W. Vogel............	1875	Washed and stained collodion films	7,000 to 3,900 solar.
Huggins	1876	Wet collodion	Not defined. stellar.
Rand Capron............	1877	Wet collodion	4,500 to 3,900 spark and arc.
Hartley and Huntington ..	1878	Gelatine emulsion...........	4,800 to 2,000 spark & absorption
Parry and Tucker	1879	Gelatine emulsion...........	5,892 to 3,900 flame and spark.
Huggins	1879	Gelatine emulsion...........	4,360 to 3,400 flame and stellar.
Cornu	1879-80	Washed collodion...........	4,123 to 1,800 spark.
Abney	1879-80	Collodion emulsion	12,000 to 7,000 solar and arc.

Others who have employed gelatine emulsion, and have investigated the ultra-violet end of the spectrum more recently, are Professors L. Soret, Liveing and Dewar, Rowland, Dr. Hasselberg, and V. Schumann.

E. Bequerel applied photography to the investigation of the spectrum very soon after the discoveries of Niepce and Daguerre rendered it possible ("Bibliothèque Universelle de Genève," vol. 40, p. 341). He sensitised his silvered plates with iodine monochloride; he exposed them to the more refrangible end of the spectrum only a few seconds, but for rays less refrangible than wave-length 4,500 a prolonged exposure was necessary. He also made use of paper sensitised with silver bromide and silver iodide. Miller's photographs were defective in consequence of but few lines on each plate being in focus, and moreover, he used too wide a slit and a spark scarcely sufficiently powerful; the lines are all duplicated by the double refraction of the lens and prism. Nevertheless, the germ of all this subsequent work is contained in Miller's paper, which included the examination of pure metals, of alloys, and the absorption spectra of some metallic salts and organic substances. To Professors Stokes, Mascart, Soret, and Cornu, we are indebted for such improvements in instruments and knowledge of the ultra-violet rays that work at the most refrangible region has become much easier than at the visible end of the spectrum. Cornu was the first to devise a means of constructing quartz prisms capable of giving a pure spectrum. He also first achromatised quartz lenses by means of colourless fluor-spar, and with calcite. Dr. W. H. Stone likewise proposed to use calcite to achromatise quartz. Cornu obtained photographs of the solar spectrum perfectly in focus from end to end, and, moreover, obtained impressions of the very highly refrangible rays of zinc and aluminium which are absorbed by a layer of air only three feet in thickness. By the term "washed collodion," which indicates his photographic process, it is intended to signify the fact that when a collodion plate is removed from the bath of silver nitrate, it is covered with a sufficient layer of the salt to prevent the penetration of the ultra-violet rays to the silver bromide in the film beneath. The silver nitrate was, therefore, washed off with water previous to exposure of the plate in the camera. Messrs. Parry and Tucker (*Engineering*, vols. xxvii and xxviii, February, May, and August, 1879) employed ordinary spectroscopes and Swan's gelatine dry-plates. They succeeded in obtaining photographs both from metallic points and from solutions. For the latter they made use of Bunsen's electrodes, which are cones of carbon, generally drawing charcoal, saturated with metallic chlorides dissolved in water. An uncondensed spark from an induction coil is passed between the charcoal cones and a platinum wire fixed about six millimetres above it. Lastly, we come to the use of dry collodion films, in which silver bromide precipitated in a particular manner is used for securing impressions of the red and infra-red rays. The sensitive salt is contained in a collodion film made with very little pyroxyline. Such plates have been used by Captain Abney and General Festing for the examination of obscure absorption bands in organic substances.

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* The decimal subdivisions of a metre are conveniently termed *metrets* (Johnstone Stoney). The first metret is a decimetre, the second metret is a centimetre, the third metret is a millimetre, and so on. A tenth metret = $(\frac{1}{10})^{10}$ metre = one-ten millionth of a millimetre.

When produced by electric sparks of high tension, emission spectra are most abundant in rays of high refrangibility, and it is comparatively of little importance whether we are able to photograph rays of greater wave-length than 6,000 tenth-metrets, while it is in the highest degree desirable that lines lying between wave-lengths 4,000 and 2,000 should be observed. For this purpose, glass, which transmits no rays beyond wave-length 3,400 should be discarded as unsuitable for lenses and prisms. By the use of diffraction mirrors there is a considerable loss of light, so that they do not present the advantages which are to be found in their use when working at the less refrangible end of the spectrum, where great dispersion is obtained. The most suitable materials for prisms are Iceland spar and quartz; the former gives great dispersion, but it is of a fragile nature, and the surface is easily corroded by acid vapours; it has also the disadvantage of not transmitting rays of shorter wave-length than 2,130; for general purposes, however, this extent of spectrum is quite sufficient. Furthermore, only those rays for which the prism is at the minimum angle of deviation are singly refracted, and hence perfect definition cannot be secured by photographing the whole extent of a spectrum on one plate. When quartz is used, the prism must be made according to Cornu's plan, of two halves, one of right-handed the other of left-handed rotation, in order to secure single refraction; the lenses likewise must be of equal thickness and of opposite rotation. Colourless fluor-spar free from blemishes is of extreme rarity, and is not available for achromatising lenses, and calcite does not afford good results when a considerable extent of spectrum is to be photographed on one plate.

THE INSTRUMENTS.—PRINCIPLES OF CONSTUCTION.

In working on the ultra-violet spectrum with uncorrected lenses, we have to take into account an effect due to the great difference in focal length between the least and most refrangible rays. In photographing the visible spectrum with achromatic lenses, this can readily be corrected by the ordinary "side swing" of the back of a well-made photographic camera. It was found by experiment, with a lens of thirty-six inches focus for the line D, that the difference in focal length between this and the most refrangible ray of cadmium was about six inches. The focussing screen, therefore, was placed at such an angle that a mean position was secured for refracted rays lying between the two extremities of the cadmium spectrum. It was then proved, by taking photographs, that the locus of the foci of these rays lies so nearly in a straight line, that even the slight curvature caused by the pressure of the spring which holds the plate in position in the dark slide is sufficient to cause the lines to become indistinct in the photograph. The dimensions of the plates were 12 in. × 4 in.

In January, 1878, a paper by M. Sarasin was published ("Archives des Sciences Physiques et Naturelles, Genève," vol. lxi., p. 109), giving the result of his determination of the refraction indices of quartz for the ordinary and extraordinary rays in the ultra-violet spectrum.

By the aid of a Table which he gives, it is possible to calculate the position that a photographic plate should take in order that any particular ray may be in focus. This Table is quoted in full in the next column, with the addition of the wave-lengths of the lines.

From this it may be ascertained that the focal distance for a 36-inch lens would, for the cadmium line 26, with wave-length 2144·1, be 31·3 inches, and for a 15-inch lens 13 inches.

With a quartz prism of 60°, the angle which that half of the plate on which lies the most refrangible part of the spectrum must make with the direction of the mean ray, varies according to the position of the collimator, between 19° and 24°, with lenses of fifteen and thirty-six inches focus. The camera back is, therefore, constructed so as ordinarily to take up this position, but it is made to swing on a vertical pivot exactly situated at its centre. The centre of this pivot is in the same vertical plane as the centre and front surface of the focussing screen, which again, as is usual, corresponds with that of the photographic plate.

The first thing to be done in adjusting the camera is to place the prism at the angle of minimum deviation for the mean ray, say, line seventeen of cadmium, then the ray is brought into the centre of the focussing screen, and carefully focussed by a backward or forward motion of the camera body communicated by the focussing screw. After this the "side-swing" enables the extreme of both ends of the spectrum to be brought into focus.

Co-efficients necessary for the determination of the focal length of a quartz lens for the ultra-violet rays of cadmium, its focal length for the ray D being known.

Numbers referring to the lines of Cadmium Zinc and Aluminium.	Wave-lengths.	Co-efficients.
9	3609·6	0·9657
10	3465·4	0·9612
11	3402·9	0·9590
12	α 3260·2 β 3257·8 γ 3249·5	0·9531
17	2747·7	0·9262
18	2572·2	0·9127
23	2313·6	0·8863
24	2265·9	0·8803
25	2194·5	0·8707
26	2144·1	0·8632
27	2098·9	0·8561
Zin. 28	2063·4 2061·0	0·8498
29	2024·3	0·8429
30	1988·	0·8363
Al. 31	1933· 1928·	0·8245
32	1860· 1852·	0·8062

The focal length of the lens for the line D should be multiplied by the co-efficient opposite the ray the focal distance of which is required to be known.

It is necessary, in order to get the best results, to make the collimator tube of equal length to the camera, measuring the focus from the lens to the slit, and the latter from the lens to the centre of the plate. The collimator tube, therefore, should be divided and fitted with a rack and pinion adjustment. The final adjustment requires to be carefully made, the plate being moved millimetre by millimetre, a box-wood or paper scale being fixed to the camera for the purpose of registering its position. Should the camera and collimator be of unequal lengths, it is advisable to find the total length of the two; halve this, and adjust each accordingly. The whole operation of focussing is somewhat tedious and troublesome, but when it is once accomplished the instrument need never be disturbed. In all cases it is best to place a condensing lens of about three inches focus in front of the slit. I have been in the habit of using a double convex lens of 2½ inches diameter. It would be a decided advantage if all spectroscopes had a sliding rod fitted to the collimator, to which a lens of the kind might be attached. If it be placed on an independent stand, it is apt to get out of adjustment.

Details of construction of the camera for lenses of long focus.—In Figs. 1 and 2, the elevation and plan of this instrument are seen. The body consists of two parts supported on a wooden stand. The portion M is a rigid shallow box, in the front of which is the lens in its fitting N. The portion of the body L, a continuation of M, is triangular in form and moveable in two directions. It is made to approach or recede from the lens by the screw K, and to make a greater or lesser angle with the directions of the mean ray X—N by turning on the vertical pivot, the centre of which is situated at X. The two portions of the camera are united by a bellows-body of leather of about three inches in length which admits of sufficient play for all the purposes of focussing. The bellows-body slides by means of a metal frame into position on the front part of the camera. In the drawing the slide is represented as not being pushed quite into its proper position, the reason being that the slant which is given to the back of the camera caused the leather portion to be inconveniently tightly pressed on one side, and as widely extended on the other. The flexible part might with advantage be made a little longer. The sensitised surface of the glass plate, when in position, is indicated by the dotted line passing through X. The screws A A serve to clamp the "swing-back" of the camera in position.

Fig. 1.

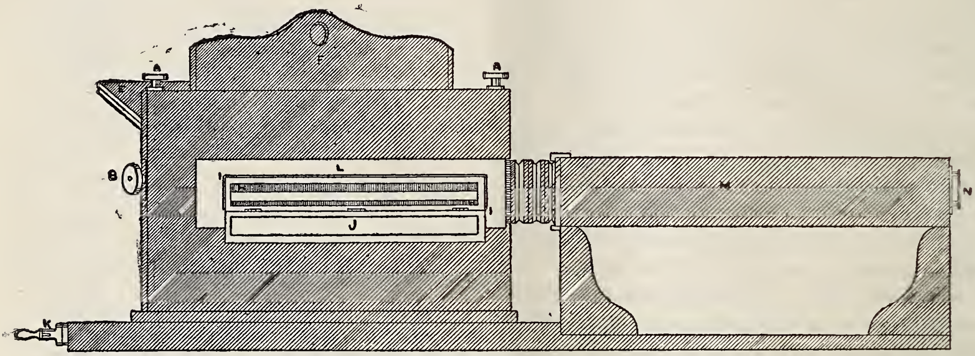
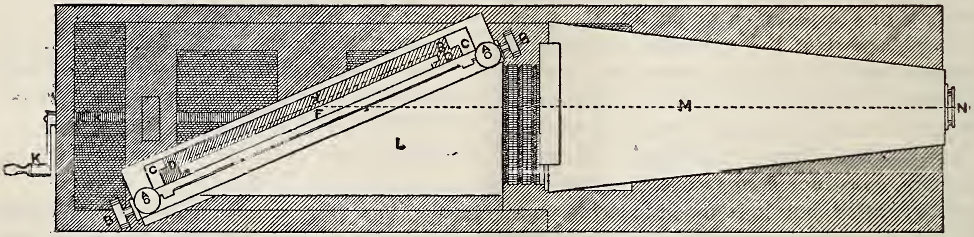


Fig. 2.

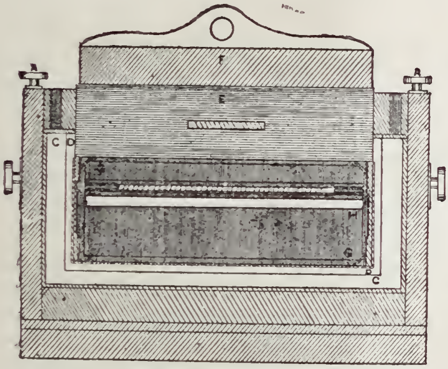


Elevation and Plan of Camera for photographing ultra-violet spectra.

It will be seen in the elevation that the camera-body is raised on supports above the flat stand, but that the camera-back, into which fits the dark-slide, is continuous above and below the camera-body. This arrangement enables one to obtain several photographs on one plate by moving down the frame carrying the dark slide by means of a rack and pinion. Thus in the elevation of the camera-back, which is open, C—C (Fig. 3, p. 401) is the moveable frame work, D—D is the dark slide, B B are the thumb screws, and passing across is seen the pinion which works in the rack on the front edge of the dark slide. The interior edge of the dark slide is shown in shadow by G G, while H is the slit in the camera-back through which the spectrum is projected. E and F represent the door at back and the sliding front of dark slide respectively. In the elevation an opening, I I (Fig. 1, p. 400), in the body of the camera, and door to the same, J, through which is seen the slit H, by which the spectrum passes to the sensitised plate. In the act of focussing, a glass plate covered with some fluorescent substance is placed in the dark slide, and the lines of the spectrum are viewed by reflection from its surface by looking through the opening I I.

A good screen, made by Professor Liveing, was exhibited at the Royal Institution. It consists of coarsely powdered uranium glass spread over a sheet of cardboard covered with glue; it is placed in the same position as a sensitive plate, and is viewed by looking through the side of the camera.

FIG. 3.



BACK OF CAMERA WITH DARK SLIDE IN POSITION, WITH THE BACK AND FRONT SLIDE OPEN.

Fitting of Prisms and Lenses.—The collimator tube and prism is not figured in the cut. I have introduced a new method of mounting the optical train which appears to be satisfactory. The quartz prism of 60° is composed as already described of two halves of opposite rotation. For the large camera a brass frame has been constructed, which fits on to the front of the camera, and is held in position by a single screw. This carries the two lenses, to each of which one-half of the prism is fitted, that face which is at right angles to the base of the prism being tangential to the curvature of the lens.

The lens and half-prism attached to the collimator is free to move through a divided arc, so that it may be placed at the best possible angle and clamped in position. The lens frame carries about two inches of the collimator tube. The remaining length of the collimator is placed on a separate stand, and is made to slide on to the short tube attached to the lens frame, as soon as the proper position for it has been secured. The arrangement admits of the minimum angle of deviation being easily found, for it is that angle at which the mean ray falls on the centre of the sensitive plate, the spectrum being as short as possible; and the whole of the optical train can be detached from the camera and cleaned without derangement of the prisms or the collimator. This is of importance, because it is so difficult, on account of the oblique position of the sensitive plate, to secure the same relative position of all parts of the instrument when once they have been disturbed, and disregarding any other inconveniences that may thus arise, a new interpolation curve would have to be drawn after any such alteration. Latterly, I have found it advantageous to mount the camera on an iron frame instead of leaving it on the wooden stand. This frame falls into position on an iron table, to which the detached collimator is also fitted. The chief advantage of this stand is that the whole instrument can be easily taken to pieces and set up elsewhere in perfect adjustment without trouble, for the parts which determine the position of the camera and collimator, though moveable, are capable of being firmly screwed to the iron table, and remain there when the camera and collimator are removed. Care should be exercised in securing prisms cut perfectly true at the base, in addition to having good faces.

The Collimator.—No matter what may be the length of the collimator, it must admit of being fixed at the minimum angle of deviation for the mean ray, and be fitted with a graduated draw tube, so that the length of the collimator may be adjusted carefully to the exact focal length of the lens for the mean ray. The end of the collimator must slide into a little box immediately behind the slit, or an opening is cut in the tube of about one-third its circumference in width and two inches in length, which may be closed by a sliding cover. The purpose of the box or opening is to enable the experimentor to judge in what direction to move the electrodes, so that the spark may fall exactly upon the slit and pass along the axis of the collimator. This is done by means of a piece of card, which fits just inside the box or opening in the tube, and has a vertical line ruled down its centre; when the spark is properly adjusted, a spindle-shaped bundle of rays strikes the centre of the card.

The Slit.—In order to obtain good definition, it is of great importance to have the slit not only well constructed, but the aperture must be adjusted, if necessary, to the thousandth or two thousandth of an inch in width. I have used fixed slits covered with plates of quartz as a protection against dust, their width ranging from 1-1000th of an inch to 1-500th, and 1-50th. I have also used a "solid slit," which was originally designed for the micro-spectroscope.* This consists of an equilateral and equiangular prism of quartz, with an edge parallel to the base of the prism, just slightly ground off and polished. This is fitted into a metal frame, so that the base of the prism is exposed and the ground edge is within the collimator. The faces through which it is undesirable that side lights should pass are blackened. To clean the slit, the exposed surface is simply wiped with a leather. Another form of slit was made for me by Mr. A. Hilger, the jaws of which are thin plates of iridium, one of the plates is moveable, and can be adjusted to the 1-80th of a millimetre by a micrometric screw, this is equal to 1-2,000th of an inch. I find that, with lenses of 15-inch focus, the cadmium lines 9 and 10 can each be divided into two lines with a slit 1-1000th of an inch in width, if the instrument is properly adjusted; and that there is not much gained by working with a narrower slit. (For the construction of slits see Parry and Tucker's "On the Application of the Spectroscope to the Analysis of Iron and Steel," *Engineering*, May 23, 1879; Schumann's "Spaltschlitten für Keil und Parallelspalt," *Photographisches Wochenblatt*, Feb. 26, 1885.) In all cases it is necessary that the instrument should be placed either upon a solid brick or stone floor, a table on such a floor, or on a bracket built out of a wall. No wooden floor of ordinary construction is at all steady. It must not, however, be inferred that a room cannot be so built as to be steady enough for the purpose; most excellent results have been obtained when working on a massive table in a small room with a very well-constructed wooden floor. Every laboratory spectroscope should be a spectrometer, that is to say, an instrument capable of giving the wave-lengths of lines not recognisable by reference to a drawing or comparison spectrum. The prism should divide the D line when a narrow slit is used. The average degree of accuracy attainable throughout the visible spectrum should not fall short of a millionth of a millimetre of wave-length, the actual measurements being reduced to wave-lengths by an interpolation curve, which is drawn from the measurements of a number of known lines regarded as fixed points on the scale. This means that the spectrum from the extreme red to the violet should be divided into 4,000 parts. Even instruments intended for the execution of measurements are frequently defective in one or more of the following particulars:—

1. *Instability of the Stand.*—This should be a well-spread tripod, fitted with levelling screws, and with a massive pillar to support the prism table.

2. *Want of proper support for the Collimator and Telescope.*—The collimator should be capable of being fixed in position in such a manner as to be absolutely rigid when in use. The telescope should be supported to within one-third of its length from the eye-piece, otherwise the act of focussing by means of a rack and pinion displaces the tube. When the position is secured, the screw should be capable of rendering the arm which carries the telescope immovable.

3. *The jaws of the slit open from one side only.*—The jaws should open symmetrically on each side of the ray of light which falls on the slit, otherwise when the slit, which has been opened in order to observe a faint or nebulous line, is closed to observe a fine brilliant line, a re-adjustment of the spark is necessary. The slit is better if adjustable by a micrometer screw.

4. *Inconvenient position of the divided circle or arc.* — When measurements are made on an arc, the divisions are generally on the horizontal surface of the prism-table. In order to take readings after an observation, it is necessary to rise from one's seat at the telescope, and scan the divided scale with a lens. The inconvenience of this can be understood by those only who have spent weeks and months at such an instrument, making and confirming readings of lines alternately obscure and brilliant. If the divisions are on the prism-table, they should be engraved upon its edge; the edge may be vertical or inclined at an angle of 50°, as in the fine instrument exhibited by Mr. Hilger in the Inter-

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* I have endeavoured to ascertain by whom this useful contrivance was first described at a meeting of the Royal Microscopical Society, but searching through fourteen volumes of the *Journal of Microscopical Science* has not afforded the information.

national Inventions Exhibition. I prefer to have the divided circle below the prism-table slightly raised above the levelling screws of the tripod. A great inconvenience arises occasionally when the divisions are not degrees of arc; this, indeed, amounts to a serious disadvantage in working with diffraction spectra. The laboratory spectroscope made by Merz, of Munich, is an excellent instrument for the chemical laboratory, but the photographed scale might be more finely divided, and a rack and pinion adjustment to the telescope should be fitted with a cross-line eye-piece magnifying ten diameters. The instrument used by Lecocq de Boisbaudran was made by Duboscq, and it answers this description. An excellent plan when great accuracy is not required has been used by Professor J. Emerson Reynolds, F.R.S. (See Phil. Mag., Fifth series, vol. v, p. 106.) In order to secure correct readings on arc or scale, it is necessary to divide the draw-tube of the telescope so that on different occasions when a given ray is observed exactly the same position of the eye-piece may be attained. After some time the eye, possibly through fatigue, fails to appreciate the sharpness of the lines so perfectly as at first; at any rate, the focus requires to be altered in order to secure distinctness of vision. This is particularly the case after observing at each end of the spectrum. Alterations in the position of the eye-piece alter the position of the lines in the spectrum with respect to the cross lines; such alterations are made by the observer when focussing, and render it very difficult sometimes to obtain concordant readings. With uncorrected lenses, a divided telescope and collimator tube are both absolutely necessary. Even with achromatic lenses the accuracy of successive readings is not to be depended upon, unless the tube is divided and always set at the same division when observing the same line. The very fine spectrometer, with a quartz train, made by the Société Génévoise pour la Construction d'Instruments de Physique (figured at page 37 in their catalogue), is graduated for the line D, and the rays of cadmium, zinc, and aluminium, Nos. 9 to 31. In all cases the milled head for the rack and pinion movement should turn as easily as that on a microscope, and in like manner the eye-piece should be as easily moveable, otherwise it is very difficult to take measurements.

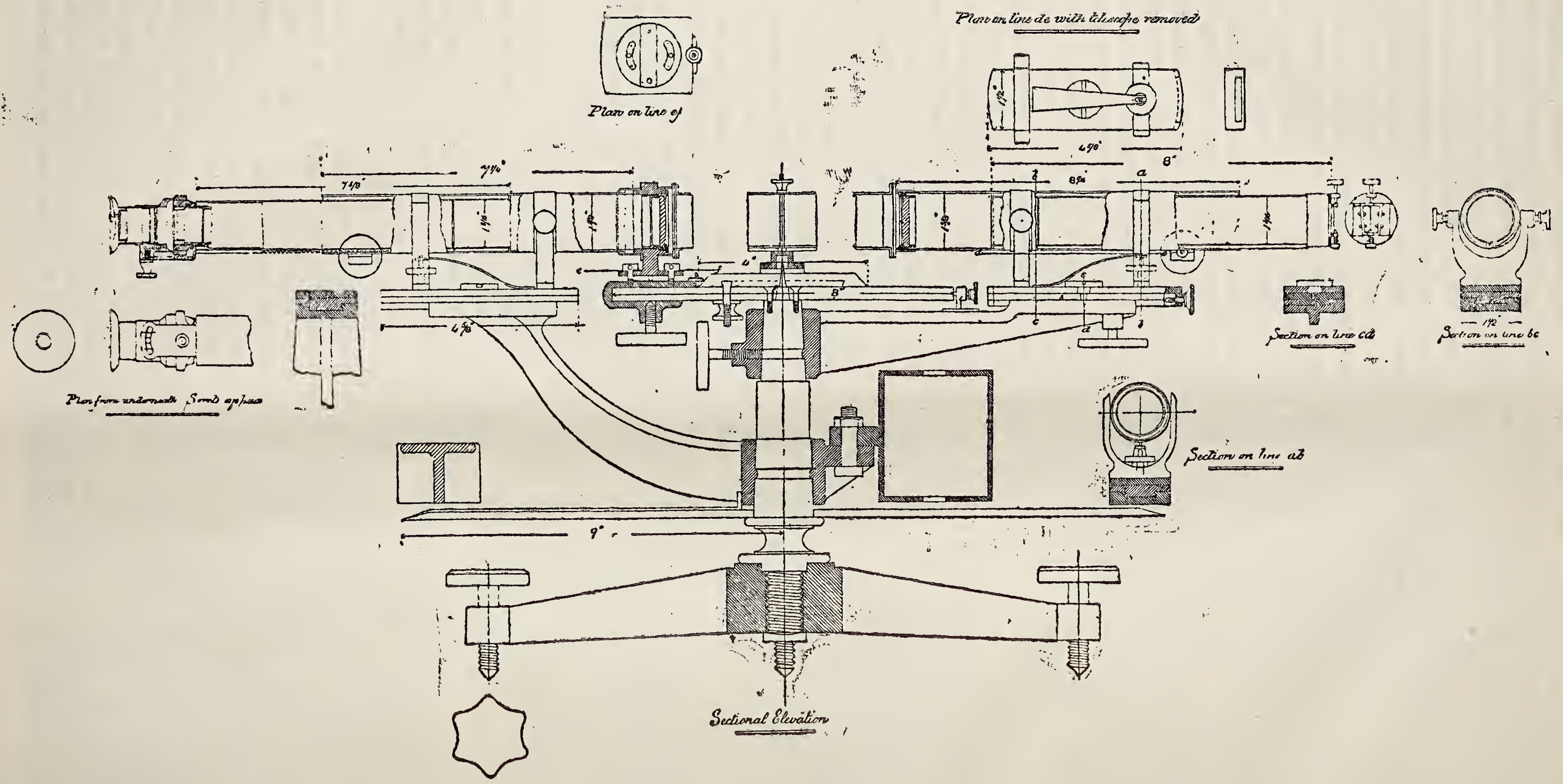
The instrument shown in Fig. 4 was designed for lightness, portability, perfect steadiness, and rigidity of the moveable parts. It may be taken to pieces, packed up, and easily removed. It is intended to serve as a spectroscope of the ordinary form, for ultra-violet rays, as a spectrograph and a spectrometer. It may be used with one, two, or three prisms of quartz or Iceland spar, or with a diffraction grating. The telescope is in position for use with an eye-piece of Soret's pattern. For observing the ultra-violet spectrum there are two half-prisms of quartz of 30° each, and one prism of 60°; the halves are attached to the collimator and telescope. The lens, which is independent of the telescope, may be clamped by the screw beneath the table; the union is then unscrewed and the telescope removed; the camera slides on to the stand previously occupied by the telescope, so that observations may be continued by means of photography. A tension screw for slow motion is not shown in this drawing.

There is a counterpoise to the camera and telescope, which is placed as low down as possible, and near to the centre of the tripod, in order to secure steadiness for the instrument. Just beneath the counterpoise is placed a divided circle of nine inches radius; it is entirely protected by a plate which of course is open at those parts where there are verniers. Being attached to the curved arm, the plate with verniers follows the movement of the telescope.

The telescope and collimator are shown drawn out to their fullest extent; each have a rack and pinion adjustment. An engraved millimetre scale indicates the correct focal distances on the tubes for the lines D, F, H, and the cadmium lines Nos. 9, 10, 11, 12, and so on up to aluminium No. 31.

It has been found more convenient to have independent lenses for the camera and telescope, and to work by photography instead of with a fluorescent eye-piece. The slit opens symmetrically by means of a screw, which is better if a micrometer; it is closed by a spring. The centre of the instrument, a point to which the pillar is turned, passes through the table and the prism plate, and is seen beneath the bridge upon which the prism is fixed. Both telescope and collimator are supported on trunnions, or pointed screws which fit into holes in the tubes, as may be seen in the cross section on line *b c*. A guide for the tubes in a vertical direction is shown in the cross section on line A B. A screw beneath raises or lowers the tube, and a spring keeps it in position. The section on line *d e* shows where the upper portion of the slide carrying either the tele-

FIG. 46



SECTIONAL ELEVATION OF AN INSTRUMENT INTENDED FOR USE AS A SPECTROMETER OR SPECTROGRAPH.

scope or collimator may be caused to move through a small arc round the centre of the screw shown in the section. A clamping screw is shown at the end of the slide which screws into the lower half; the upper half of the slide has a slot where it overlaps the other, as may be seen in the drawing, where a portion of the end of the slide is shown in section, also in the plan of the slide where an end view shows the slot. The plan on line *d e* shows the spring used in levelling the tubes.

THE METHOD OF SPECTRUM PHOTOGRAPHY.

The character of a photographed spectrum depends, 1st, on the nature of the salt or salts in and on the surface of the sensitive film of the photographic plate; 2nd, on the diactinic character of the vehicle used for the emulsion; 3rd, the period of exposure of the film to the active rays; 4th, the diactinic character of the optical train; and 5th, the rates of vibration of the emitted rays. Given an optical train as diactinic* as air, and a sensitive salt capable of receiving an impression from all rays transmitted by the instrument, and we may regard the photograph of a spectrum as a permanent record of a chemical reaction distributed in time and space.

In the year 1878, I executed a series of photographs which showed variations in the number, length, and strength of the lines in the ultra-violet region. These photographs proved that by alterations in the exposure of the photographic plates certain impurities became visible in metals otherwise apparently pure, without any changes being noticeable in the spectra, such as might be introduced by over exposure. Thus, by increasing the period of exposure threefold, the lines of iron were plainly seen in a spectrum regarded as that of pure aluminium. Two specimens of indium were examined. They both yielded the flame spectrum and the reactions usual with this metal; one of them showed no strong lines in the ultra-violet which could not be attributed to tin, lead, or cadmium; the other contained tin and cadmium in such proportions that the lines of these metals were more prominent than those of indium. A third specimen, prepared by Professor Richter, of Freiberg, yielded no spectral lines which could be attributed to any foreign metal.

Manipulation necessary to secure sparks of constant intensity, &c., &c.—The battery power, size of coil, and condensing surface must all be proportional to the distance between the electrodes. When the battery power is too weak, the stream of sparks is intermittent, and with badly conducting electrodes may cease altogether.

The rapidity of the passage of the sparks should be so great that the light appears to be continuous. The coil should be capable of giving a six-inch spark in air, and it is better to excite it with a storage battery than with five cells of Groves' battery. Three storage cells, with an electromotive force of 1·8 volts, are generally sufficient for a coil of this size of Apps' make. As the battery runs down, the number of cells may be gradually increased. According to some measurements which were kindly made for me by Professor Barrett, the current required to work a coil is $7\frac{1}{2}$ to 8 ampères. Three storage cells yield $15\frac{1}{2}$ ampères. With a resistance of half an ohm in circuit, the current is reduced to 7 ampères; hence it is found convenient to introduce a resistance of a quarter of an ohm, which is accomplished by passing the current through two carbon rods placed side by side, their length being 12 inches, and their thickness that of an ordinary lead pencil.

This arrangement works satisfactorily. The smallest condenser which can be employed with advantage has 72 square inches of tinfoil on each side of a pane of glass. It is fixed in a picture frame, with binding screws attached to the wood. Leyden jars should not be used, as they entail much annoyance from the inside connections burning. Particular care is necessary to keep the slit free from dust, the condensed vapour of volatile metals, and splashes of liquid. The slit may be covered with a plate of quartz cut as thin as possible without using extraordinary care. The condensing lens is of great use as a protection to the slit.

When the electrodes wear away by reason of the excessive volatility of a metal, sometimes a portion of the spark does not fly directly opposite to the slit. Good, thick, and broad electrodes are commonly productive of the most uniform results. The character of the lines varies with the conductivity and volatility of the electrodes; their intensity, as a rule, increasing with these properties.

For obtaining sparks without a condenser, but giving characteristic spectra, M. Lecocq de Boisbaudran uses a concentrated solution contained in a glass tube, through the bottom of which passes a platinum wire which is fused into the glass. The wire is connected with the negative pole of an induction coil, the positive pole terminating in a wire placed conveniently above this. A well-known modification of this is the tube of MM. Delachanel and Mermet (Schutzenberger's "Traité de Chimie Générale," vol. i., p. 284), but as the rays must necessarily pass through glass, it is not adapted to the examination of ultra-violet spectra. Any method is disadvantageous which necessitates the use of platinum electrodes with a condensed spark, since the number of lines belonging to this element is embarrassing when they have to be eliminated from the spectra of other bodies. Of all metals affording materials for electrodes gold appears to be the best; its spectrum is a weak one, containing comparatively few long lines, it is an excellent conductor of electricity, and it is not attacked by solutions of metallic chlorides. Wicks of gold wire have been used by me, the metal projecting just above the surface of the solution.

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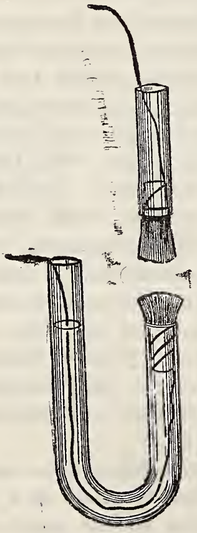
* The word diactinic is used to denote what might perhaps be termed "transparency to the ultra-violet rays," from διὰ, right through, and ἀκτὶς, a ray. Actinic absorption means the reverse of this. The expression "actinic rays" should abolished as simply nonsense.

Fig 5.



Graphite Electrodes for use with Solutions. The U tube is charged with liquid.

Graphite yields the simplest spectrum ("Note on Certain Photographs of the Ultra-Violet Spectra of Elementary Bodies," *Journal of the Chemical Society*, vol. xli., p. 90) when pure. It shows lines and the edges of bands due to the air-spectrum to the number of sixty-six, of rays assignable to carbon it contains but twelve. Graphite being an excellent conductor of electricity, electrodes are made in the simplest possible manner by cutting plates of good Ceylon or Siberian graphite, tapering from one-fourth to one-eighth of a inch in breadth and three-eighths of an inch in length. Deep grooves or scratches are made in the sides of the lower electrode, which is inserted into the end of a small glass **U** tube containing the solution. The upper pole which may be made of graphite, is fused into a glass tube or held in a screw clip. Platinum terminals of very thin wire attached to those proceeding from the coil are connected with the electrodes. Capillary attraction keeps the lower electrode moist at its upper surface. Such electrodes have been constantly in use for producing sparks from which photographs of the spectra of saline solutions have been taken. Fresh electrodes have generally been made for each solution, but they may be used over again repeatedly, provided they be well washed with hydrochloric acid and water. The only objection to them is that they are not permanent, but in course of time burn away or disintegrate. Each of the two pieces of graphite should be sharpened so as to resemble a chisel, the edge of the one being exactly superposed to that of the other, while both are placed in a line with the slit; the movement of the spark is thus restricted to a direction backwards and forwards, but always in front of the slit and not to one side or the other.

Of course it is necessary to ascertain that the specimen of graphite used does not give any of the numerous lines in the spectrum of iron when the electrodes are moistened and the spark is passed. The only two lines of a foreign element plainly visible in the spectrum of very pure graphite are generally the first and third of the quadruple group in the magnesium spectrum, with wave-lengths 2794·4 and 2801·1. Faintly seen are the second and fourth lines, wave-lengths 2796·9 and 2789·6. The same piece of graphite may not be of equal purity throughout.

Conditions Necessary to Secure the Best Results.

It has already been mentioned that a dense and brilliant spark must be produced, the light from this must be concentrated on the slit by means of a lens, the slit must be sufficiently narrow, that the prism at a minimum angle of deviation for the mean ray, and the collimator and distance from the lens to the plate of equal length. As the rays condensed by the lens must pass axially through the collimator tube, the condensing lens must be so carefully adjusted that a horizontal line from the centre of the spark is transmitted through the centre of the condensing lens, the centre of the slit, and the lens behind the prisms. For securing these conditions, it would be a great convenience if the condensing lens were fitted to the collimator by a square rod, upon which it could slide out to its proper position; the spark could then be easily adjusted, until its image fell directly upon the slit. The finest definition is secured by the lenses of the collimator and camera being of eighteen inches focus for D, and two inches in diameter. The base of the prism, as already mentioned, should be cut so as to be at right angles to the faces, and the prism must be levelled. If this be not the case, the lines of the spectrum slant, and are deficient in definition. The length of the spark is of some importance, because if too long its path is irregular, and it is wanting in thickness; it jumps, therefore, from one side of the slit to the other. A shorter spark is more brilliant, is thicker, and its path is straight, so that the rays play upon the slit without interruption. The length of spark found to answer is from 3-16ths to a quarter of an inch in length.

In photographing the spectra of solutions the spark must of course pass upwards, that is to say, the lower electrode must be the negative pole. I have occasionally used a vacuum tube to determine which is which, there being a non-illuminated space round the negative pole. It is hardly necessary to resort to such means if a solution or water surrounds the electrode, because when the spark passes from the dry electrode, which for the purpose had better be of graphite, the noise is less smart, and very minute yellow sparks of the burning material are seen to pass downwards, whereas when the current takes the reverse direction splashes of liquid are projected upwards and the noise is louder. Should the sparks be too long, or the current passing in the wrong direction, the constituents of a metallic solution may fail to give evidence of their presence.

The Photographic Process.—The conditions necessary in photographing ultra-violet spectra are—1st, a sensitive salt exerting an equality of action throughout the whole range of the spectrum; 2nd, a vehicle to hold the salt, which is perfectly diactinic; 3rd, a process of development which will not exert a preferential action on any portion of the spectrum.

These conditions are fulfilled by the use of pure bromide of silver in gelatine, the image being developed by pyrogallol and ammonia. Ferrous oxalate is not so suitable, because strong lines become developed much more strongly than weak lines, and such are always present in the spectrum of air extending from wave-length 4200 to 3500. The exposure varies a little with different electrodes between three and five minutes, but this depends on the sensitive nature of the plates, the excellence of the developer, the width of the slit, and the focal length of the lenses. Comparative exposures should be made at first, but it may be stated that there is but little likelihood of ill effects from over exposure, as the same spark has given excellent spectra with an exposure varying from half-a-minute to twenty-five minutes, the chief difference between the photographs being that in the latter case much more detail was observed in the spectrum. It is not worth while to use any but the best plates. Inferior or cheap plates, though sometimes yielding highly satisfactory results, are not always to be depended upon, while the best never fail to give satisfaction. They vary, however, and only twice have I obtained them sensitive to rays of lesser wave length than 2,100.

The following facts have been established regarding ultra-violet spark spectra:—

1. When carbon or metallic electrodes, which emit short lines, are moistened or partially immersed in water, the short lines are lengthened.

2. The impurities in a metal, or the minute constituents of an alloy, generally appear as spectra of short lines. When both electrodes are of the same material, the impurities appears at the negative pole only, but when the proportion of the impurity or alloy is increased, the long lines are seen as short lines at both poles, a further increase in proportion brings them out as long lines.

3. Of the non-metallic elements, boron, carbon, and silicon, exhibit line spectra.

4. The spectra of carbon and silicon may be detected in photographs taken from metallic electrodes such as those of iron wire.

5. Insoluble compounds which are not volatile, such as ferrous sulphide, ferric oxide, and ferrous phosphate, do not yield spark spectra. Insoluble though somewhat volatile compounds, such as thallium chloride, yield a feeble spectrum of the metallic lines.

6. With the exception of boron and silicon, the non-metallic constituents of a salt do not affect the spark spectra of solutions.

7. The solution of a metallic chloride, nitrate, or sulphate, yields spectral lines identical in number and position with the principal lines of the metal itself. Some of the short lines become long lines, but whether the spectra are produced by metallic electrodes or solutions, their character is identical.

8. The effect of diluting solutions of metallic salts is first to weaken and attenuate the metallic lines, then with a more extensive dilution to shorten them, the length of the longest and strongest lines generally decreasing until they finally disappear. There are two lines of copper which disappear by attenuation only, they do not shorten; and a similar pair of lines in the spectrum of silver behave in a like manner. Both pairs of lines have been observed as short lines in alloys containing very small quantities of these metals.

9. Accidental differences in the passage of the spark, or in the time of exposure of the photographic plate, when the normal period is from half-a-minute to five minutes, do not cause sensible variations in spectra obtained from the same substances, under any ordinary circumstances.

10. Spectra of metallic electrodes and of solutions are liable to the presence of the lines of calcium, at wave-lengths 2967·3 and 3933, also, occasionally, at 3736·5, and 3705·3 (Cornu's measurements). These calcium lines are due to dust when the electrodes are dry, or to impurities in the acids when solutions are prepared therewith and examined.

THE EXAMINATION OF METALS AND ALLOYS.

When a substance of metallic character is to be examined it may be filed or beaten into electrodes of a convenient size and shape, and held between screw clips, or between the points of a cheap drawing pen. According to circumstances one electrode may be used of another metal such as gold, platinum, or a tin-cadmium or lead-cadmium alloy, containing in each case 20 to 25 per cent. of cadmium; or one of the electrodes may be a piece of graphite. If it be required to bring out the constituents of the alloy present in minute quantity or the impurities in the metal, it is best to partially immerse the lower electrode in water, contained in a small glass tube, as if a solution were being photographed; under these circumstances the short lines become much lengthened, and become much more prominent. The best form and size for the electrode is something like that of the electrodes of graphite already figured, the edges being sharpened like a chisel. Of course there is no necessity for the grooves, but it is better to have the corners rounded since there is sometimes an irregular discharge from the points. The method of obtaining spectra from solutions has already been dealt with.

Some years ago Mr. Norman Lockyer, who first directed attention to the occurrence of long and short lines in the spectra of pure metals, was impressed with their importance as an idea of the quantity of material present in the arc or spark. At a later date, Messrs. Lockyer and Chandler Roberts-Austen made eye observations on the spectra of several zinc, cadmium, gold and copper alloys. They contrasted the usual method of assaying with that dependent on the use of the spectroscope. The former comprises six operations and occupies a period of two hours before the final result can be stated; the result by the latter mode of operating may be made known in a few minutes. They claim to have clearly established the fact that it is possible to detect, by this means, differences in the composition of a gold-copper alloy as minute as 1-10,000th part of the whole mass. ('Phil. Trans,' vol. clxiv, p. 495, 1874.) The precise method of observation is not described, it may have been a measurement of the intensity of the long gold lines, a measurement of the short lines, or a measurement of the length of, or of the intensity and thickness of the long lines. On the other hand, the observations may have all been directed towards the lines of copper, the whole or the majority of which would appear as short lines, according to the quantity of alloy present.

Mr. Henry Pizey, Assayer to the Company of Goldsmiths, Goldsmiths'-hall, who originally assisted Dr. W. A. Miller in his similar investigations, was good enough to prepare for me specimens of gold corresponding to the five standards, namely 22, 18, 15, 12, and 9 carat. The alloy in each case was copper. Photographs of these alloys plainly show that the very numerous lines of copper are increased in length and number as the quantity of copper in the alloy increases. Another series of photographs show the changes in the spectra of gold-silver alloys, containing 99, 98, 90, 75, and 50 per cent. of gold. By a mere inspection of these photographs, as projected on the screen, it is easy to form an estimate of the composition of an alloy, such as the one which has been photographed, and is seen to contain about 3 per cent. of silver. Jewellers' gold is generally made by the introduction of both copper and silver. This would not, however, very greatly complicate matters, since it is necessary to observe only some of the lines in each case. The maps of the quantitative spectra of silver and copper now exhibited will serve to make this readily understood.

At the present time the ordinary process of assaying appears to be of greater practical utility than any that may be dependent upon the use of the spectroscope.

THE IDENTIFICATION OF LINES IN PHOTOGRAPHED SPECTRA.

When the spectrum of an alloy, metallic precipitate, or solution, has been photographed, sometimes on account of the complexity of composition of the alloy, precipitate, or solution, or owing to the preponderance of one of the constituents, it is not easy to determine what substances are present and what are absent, even when the spectra of the substances sought for are well known. It is necessary in such cases to proceed according to one of the following two methods, or even to have recourse to both of them.

(*a.*) *Method of identifying the elements of lines photographed from a known specimen.*—A series of photographs taken from metallic electrodes and from solutions when the apparatus is properly adjusted should always be kept for reference. A substance may then be readily identified even when the wave-lengths of its lines are unknown, by superposition of one photograph upon the other, film to film, since there are but very few cases of actual coincidences of lines of similar character. On the small photographs from which copies were printed by the Woodbury process for publication in the *Journal of the Chemical Society*, vol. xli., p. 90, it is easy to distinguish with a hand magnifier lines differing in wave-lengths by only two-tenth metrets, and, of course, with a microscope and a two-inch objective the examination of the actual plates is much easier. Having examined the photograph for all the elements which may possibly be present in the spark, if there be still some lines, the presence of which cannot be accounted for, it is necessary to proceed according to the next method.

(*b.*) *Method of identifying lines when comparison spectra are not available.*—By chemical processes of separation, it is of course easy to ascertain what metals may be looked for. The wave-lengths of the unrecognised lines must then be ascertained from an interpolation curve, and this curve may be constructed from measurements made directly from the photographs by means of an ivory scale with a bevelled edge, the divisions on the scale being hundredths of an inch. With a strong magnifier we may read by judgment to tenths of each division—that is to say, to thousandths

Reference lines used in the construction of an interpolation curve.

Scale numbers. Hundredths of an inch.	Wave-lengths.	Origin of Lines.	Reciprocals.	Scale numbers. Hundredths of an inch.	Wave-lengths.	Origin of Lines.	Reciprocals.
17	4480	Mg	2232	190	2812	Sn	3556
17·7	4454	Ca	2245	192·5	2801	Pb	3571
18·9	4434	Ca	2255	197	2778	Sn	3599
20·0	4424	Ca	2260	203·5	2747	Cd	3640
20·5	4414	Cd	2265	213	2705	Sn	3696
22·5	4386	Pb	2280	223	2662	Pb	3756
30·5	4245	Pb	2355	235	2613	Pb	3827
42·7	4061	Pb	2462	240	2593	Sn	3856
62·0	3800	Sn	2503	244	2576	Pb	3882
67·3	3739	Pb	2674	245	2572	Cd	3888
72	3683	Pb	2715	245·5	2570	Sn	3891
76·3	3639	Pb	2748	247	2561	Pb	3904
79	3610	Cd	2770	251·5	2545	Sn	3929
82·7	3572	Pb	2799	266·5	2495	Sn	4008
93·7	3465	Cd	2886	270	2483	Sn	4027
97	3437	Air	2909	272	2475	Pb	4040
101	3403	Cd	2938	281·3	2445	Pb	4090
106·5	3352	Sn	2983	282	2443	Pb	4095
109·5	3330	Sn	3003	286·5	2429	Sn	4116
115	3283	Sn	3045	289	2422	Sn	4128
118	3262	Sn	3065	295	2402	Pb	4163
119·5	3260	Cd	3067	298	2393	Pb	4178
129·5	3174	Sn	3150	306	2368	Sn	4223
135	3137	Pb	3187	311	2355	Sn	4246
151	3033	Sn	3297	318	2335	Sn	4282
155	3008	Sn	3324	320	2329	Cd	4293
159·5	2980	Cd	3355	322·7	2321	Cd	4308
165	2949	Pb	3391	325·7	2313	Cd	4323
171	2912	Sn	3434	335	2288	Cd Sn	4370
177	2880	Cd	3472				
178·5	2872	Pb	3481	344	2265	Cd	4415
180	2862	Sn	3494	351	2247	Sn	4450
182·5	2849	Sn	3510	353·5	2241	Cd	4462
185	2837	Sn	3524	368·5	2205	Pb	4535
186	2832	Pb	3531	372·5	2195	Cd	4555
188	2822	Pb	3543	395	2145	Cd	4662

Fractions of a tenth-metret have been omitted from this list. The more correct numbers are to be found in the "Phil. Trans.," vol. clxxv., p. 49, Part I., 1885, where also the scale numbers are given which refer to photographs published in the *Journal of the Chemical Society*, vol. xli., p. 84, 1882. The object of these numbers is to facilitate the identification of lines, and this is further aided by a description of each line. See also "Phil. Trans.," vol. clxxv., p. 325, Part II., 1885.

of an inch. The best form of magnifier is one made like the compound eye-piece of a microscope, which is brought very close to the surface of the scale and photograph, so that false readings caused by parallax are avoided. It is most convenient if there are cross hairs or fibres of cocoon silk in the eye-piece. The following lines afford convenient points for drawing the curve. The scale numbers are of course arbitrary, the zero being fixed at any part of the spectrum where the plates cease to be sensitive. The reciprocals, which represent oscillation-frequencies in unit of time, yield a curve which more nearly approaches to a straight line than the curve of wave-lengths, as may be seen by the two curves which have been used for reducing my measurements.

Having pricked off on the photograph al[1] the lines which have been recognised, or *vice versâ*, the scale is very carefully adjusted so that it gives correct readings with lines of known wave-length at different parts of the spectrum, as, for instance, with Nos. 9, 10, 11, 12, 17, and 25 of cadmium.

In order to adjust the scale accurately, it is necessary to rule a line down the whole of the spectrum, and this can be done by placing a very fine wire across the slit, about one-fourth or one-third the length of the spark, above the edge of the lower electrode; the edge of the scale should coincide with this line. Another way of effecting this is to make a slight nick in the edge of the slit plate; the line in the first case is clear glass, but in the second it is a dark line, by reason of the slit being wider at this point. For the most part it is a continuous spectrum showing strong lines reversed.

The scale numbers of the unrecognised lines are then read off, the curve is referred to, or the wave-lengths are recorded after reference to a tabulated statement of scale numbers, and corresponding wave-lengths derived from readings on the curve. From maps or descriptions of spectra of the elements the corresponding lines are selected. The operation is performed more readily than it can be described, as will be seen later on when giving an account of the analysis of a blende. Having nothing to guide the observer but the position of the lines on the photograph and the wave-lengths deduced therefrom, it is particularly necessary to be guarded against the possibility of coincident lines or nearly coincident lines being mistaken. Any difficulty of this kind may be easily obviated if attended to.

THE APPLICATION OF SPECTRUM PHOTOGRAPHY TO MINERAL ANALYSIS.

In the ordinary routine of mineral analysis a great deal too much is taken for granted, even when the work is of a scientific and not of a technical character. Thus, in examining a mineral of the nature of a limestone, or in estimating the bases in a silicate, it is usual to regard the precipitate formed in presence of ammonium chloride and ammonia, if white, as alumina; or if slightly yellow in colour, as ferric oxide and alumina; sometimes the iron is estimated as well as separated, and the remaining base or bases are called alumina, there being no confirmatory reaction in common use beyond the solution of the precipitate in caustic alkali. Strictly speaking, no precipitate should be definitely stated as being alumina unless it has been submitted to the spectroscope, and proved to emit no other rays than those characteristic of aluminium.

In the analysis of an iron ore such as hæmatite, it is usual to estimate the iron, manganese, phosphorus, silica, alumina, and sulphur. It is rarely indeed that a qualitative examination is made, and hence there sometimes arise unforeseen difficulties. I have been informed of an instance where calamine accompanied the iron ore, and an accumulation of zinc choked the upper part of a blast furnace. Antimony has been known to occur in a lead ore to such an extent that newly-erected works had to be abandoned or extensively modified.

Perhaps the most striking instance of the value of spectroscopic analysis, though it is one of an exceptional character, is afforded by the history of the mineral rhabdophane. For years this substance remained described as a blende, until Mr. Lettsom, examining the light reflected from a specimen with a pocket spectroscope, discovered the presence in it of didymium. Subsequently an analysis made by myself, in which the spectroscope played an important part, showed it to be a hydrated phosphate of cerium, lanthanum, didymium, and yttrium. This was the first British mineral proved to contain yttrium, and the proportion of that element was only about 1 per cent.

The most rapid method of performing a qualitative analysis is one dependent on the process of spectrum-photography, and it has this advantage, that it is also, within certain limits, a quantitative method; furthermore, by the introduction of some modifications, it becomes the most accurate method of determining some of the constituents of minerals.

The process consists in dissolving one gramme weight of the mineral, and making the solution up to 1 cubic centimetre, 5 cubic centimetres, or 10 cubic centimetres, as may be expedient. Should much iron be present, this is separated by one or two analytical methods which need not be described here. Iron, cobalt, and nickel, also chromium and manganese, are metals with complicated spectra which might obscure the lines of other elements. The solution is then submitted to the spark, and its emission spectrum photographed; the photograph is examined for the lines which are known to be the most persistent or are prominent in dilute solutions of the metals.

The examination is made in the following manner: an ivory scale divided into hundredths of an inch is applied to the photograph, so that well-marked lines, such as those of air and of the carbon electrodes, coincide with their proper numbers on the scale; the photograph is then carefully scanned at all those points on the scale where metallic lines are likely to occur. One instance will serve as an illustration, because it is an example of all the difficulties which may arise in such an examination.

An Analysis of Blende.—A zinc blende found at Silver Mines, Co. Tipperary, was dissolved in hydrochloric acid, the solution was set on one side with a stick of pure zinc. The precipitated spongy metal was detached from the zinc, washed carefully, and fused on charcoal, before the blowpipe, to a globule. The metal, which proved to be hard, though it evidently contained much lead, was hammered into a convenient shape for an electrode. A spark was taken from this metal and its spectrum photographed. The Table in the next column shows the lines observed on the photograph.

By simple inspection the reference lines of cadmium were recognised, but they appeared as short lines, being in one electrode only. The scale was set so that the cadmium line 11, wave-length 3403, stood at 101. It is, of course, best to fix the scale by reference to several lines at either end of the spectrum. Notwithstanding that this was not done, the figures which represent only the one set of readings give very good indications of the wave-lengths of the lines. Below wave-length 4000, the curve cannot be expected to yield satisfactory numbers, because the deviation of the rays and the dispersion caused by a quartz prism is too slight, especially with lenses of 15 inches focal length. Between 4000 and 3000 the average difference in wave-length of 9 lines is + 0·9 tenth-

Lines observed in the Metals precipitated by pure Zinc from a solution of blende,

MEASUREMENTS OF SPECTRUM.

	Scale numbers, Hundredths of an inch.	Wave-length from measurements.	Origin of lines.	Correct Wave-lengths. (Hartley & Adeney)*	
		Tenth-metres.		Tenth-metres.	
1	43	4059	Lead	4057·5	
2	67·3	3739	,,	3738·9	
3	72·2	3680	,,	3682·9	
4	76·3	3639	,,	3639·2	
5	82·1	3572	,,	3572·6	
6	103·0	3384	Silver	3382·3	
7	115·4	3380	,,	3280·1	
8	116·3	3273	Copper	3273·2	
9	119·8	3247	,,	3246·9	
10	164·5	2950·7	Lead (?)	2949·2 (?)	
11	180	2863	Lead	2863·2	
12	186	2831·5	,,	2832 2	
13	187	2823	Copper (?)		
14	188	2821·5	Lead	2822·1	
15	192·2	2801·5	,,	2801·4	
16	222·5	2664	,,	2662·5	
17	234·5	2615	,,	2613·4	
18	243·8	2576·8	,,	2576·4	
19	247·5	2562	,,	2561·6	
20	253·3	2544	Copper	2544·6	
21	264	2506	,,	2506·2	
22	268·3	2489	,,	2489·1	
23	269	2486	,,	2485·6	
24	271·5	2477	Lead	2475·7	
25	273·5	2473	Copper	2473·2	
26	280·7	2448	Lead (?)	2445·7 (?)	
27	284	2437·3	Silver	2437·3	
28	287	2427·5	,,	2427·3	
29	289	2421	,,	2419 9	
30	291·9	2412	,,	2413·3	
31	292·4	2410	,,	2411·3	
32	296	2403	Copper	2403·3	
33	306·5	2370	,,	2371·6 2370·1	Appear as one line.
34	333·7	2295	,,	2295-0	
35	340·5	2277	,,	2277·0	
36	352	2248	,,	2248·2 2347·7	Also a lead line here.
37	353·7	2244	,,	2244 2243·5	Appear as one line.
38	369	2205	Lead	2204·3	

Indium a trace.

The precipitable metals amounted to 5·4 per cent. of the ore, and from the spectrum of these we arrive at the following result:—

Lead	5·4	per cent.
Copper	0·005	,,
Silver	0·00027	,,
Indium, a trace.		

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* "Phil. Trans.," vol. clxxv., p. 49.

metrets; the difference in 8 lines is 0; the maxmium difference is 2·9 tenth-metrets. Between 3000 and 2100 the average difference is below + 0·5 tenth-metrets in 29 lines; the minimum is 0, the maxium is 1·3. This simple method is very expeditious, the whole of the readings of 38 or 40 lines being made in twelve minutes, and the wave-lengths found in forty minutes. As for accuracy, it compares very favourably with the usual method of measuring spectra with the best instruments, and when every care is exercised.

With regard to the lines of the different elements, those of lead, the metal present in greatest proportion, are continuous from pole to pole. Those of copper and silver proceed from one electrode only, and some of these are only half lines, others mere dots.

Quantitative results are obtained by first photographing the spectra of solutions of known strength, and comparing the photograph of the substances under an alysiswith the maps of the lines characteristic of the various solutions. Under given conditions each solution emits a characteristic spectrum.

The spectra of nearly all the metals reducible by zinc have been examined in this way, together with some others, such as beryllium, aluminium, cadmium, zinc, and magnesium, also certain non-metallic elements, as silicon and boron. The delicacy of the spectrum reaction in some cases is very great, thus $\frac{1}{100000000}$th of a milligram of magnesium has been found to yield photographs of the two lines with wave-lengths 2801·6 and 2794·1, and this was well within the limits of sensitiveness. Maps of the spectra taken from solutions are published in the "Philosophical Transactions," clxxv., p. 325, 1885, and a list of the lines is given without the maps in the British Association Report for the same year.

In the analysis of the blende from Silver Mines the lines of copper and silver observed are—

Silver.		Copper.	
3384	Lines indicating between 0 01 and 0·1 per cent. of silver.	3273	Lines indicating between 0·1 and 1 per cent. of copper.
3280		3247	
2437·5		2544	
2427·5		2506	
2321		2489	
2413		2486	
2410		2473	
		2403	
		2370	
		2295	
		2277	
		2248	
		2244	

Evidence of the presence of indium, in the proportion of something like 0·01 per cent. of the precipitated metals, is afforded by the lines 3253 (3255·5) and 3037 (3038·7), but this evidence is not very strong. At the same time there is no accounting for lines at these points except by the presence of indium. The only remaining metals which might be looked for are tin, thallium, gallium, tellurium, arsenic, bismuth, mercury, gold, and the platinum metals. On first reading the wave-lengths of the lines, there appears to be a possibility of tellurium occurring in this spectrum, on account of the presence of lines with wave-lengths 3384 (3383·6 silver), 3280 (silver, 3273 (copper), and 3249 (3248·2 copper), for tellurium yields lines at 3382 4, 3280, 3273·4, and 3246·8. The evidence that tellurium is absent lies in the facts:—

1. That two lines which are very persistent lie at wave-lengths 2386·3 and 2383·8, and these are absent.

2. The copper lines 3273 and 3247 are coincident with tellurium lines, and the silver lines 3282 and 3280 are also coincident with tellurium lines.

3. The line 3246·8 is to be seen in a solution containing 0·01 per cent. of tellurium. It is the most persistent line in the spectrum.

4. The character of the pairs of silver and copper lines prevents their being mistaken for the lines of tellurium.

If it were impossible to obtain such convincing evidence as this, there would be no difficulty in preparing a fresh solution from the electrode, in separating the lead by sulphuric acid, and precipitating the remaining reducible metals by a rod of zinc, and again submitting them to the spectroscope.

In cases where the precipitate is known to be largely composed of lead, it is found convenient to use the lead-cadmium alloy for the upper electrode, since the lines which stretch across from pole to pole must belong to lead, the cadmium lines then fix the position for the scale, and all other lines belong to the metals sought for which are at the opposite pole.

Beryllium.—A few years ago some specimens of granite which came into my hands appeared to contain crystals of apatite. Four samples were examined, each weighing about 50 grammes when powdered; in only one was a small quantity of phosphoric acid found by Sonnenschein's molybdic acid method; it was too small for the amount to be estimated. Subsequently, it occurred to me that these crystals might be beryls, and as beryls are found in the granite formation of the Mourne Mountains, some of the rock from the district was analysed, and the bases submitted to the spectroscope. Two small quantities, the one "iron and alumina," the other separated "alumina" were dissolved partially by boiling with sulphuric acid; the solution of sulphates was then found to be free from beryllium salt, the alumina, of course, after ignition, was only very slightly soluble. Professor O'Reilly, M.R.I.A., has recently found beryls in massive crystals in the granite of Glencullen, near Dublin. These have also been examined by the spectroscope.

Having observed that two blocks of granite used in the construction of Kingstown pier contained crystals, which from their appearance might be either beryls or apatites, a crystal was detached by means of a penknife; its weight was 15 milligrammes. It was fused before the mouth blowpipe with a mixture of sodium and potassium carbonates mixed with a little borax. The use of the borax aids the solution of this silicate to a very great extent, and so obviates the necessity of employing a much greater quantity of the carbonates. The fused mass was treated with water and dilute sulphuric acid, amounting altogether to a volume of about half a cubic centimetre. The beryllium and aluminium lines were noted in the spectrum. The granite came from a neighbouring quarry. There can be no doubt now that the crystals mistaken for or supposed to be apatite were beryls.

The lines observed were those with wave-lengths 3320·1, 3129·9, the principal line, 2649·4, 2493·2, and 2477·7.

Pyrites.—Examples of analyses of pyrites are the following. The mineral is powdered and dissolved in nitric acid, evaporated to dryness with addition of hydrochloric acid. The salts are treated with ammonia, and afterwards submitted to the spectroscope. In this way the iron is separated, and the silver and copper are detected or estimated.

Limestone.—A remarkable mineral was examined which may be termed an amygdaloid limestone. It consisted of small almond-shaped masses, apparently of the nature of a zeolite, interspersed with a highly crystalline and almost transparent material, considered to be the matrix. It effervesced with acids, dissolving completely, and yielding no residue of silica after repeated evaporation to dryness with hydrochloric acid. A strong solution containing 20 per cent. of the solid was submitted to the spectroscope; the calcium lines came out prominently in the photograph, and, in addition, the quadruple and quintuple groups of magnesium were noticeable, but no other metallic lines.

The magnesium was estimated by dissolving one grain of the mineral in hydrochloric acid, and making the volume up to 100 cubic centimetres. The solution yielded a photograph which was compared with the photographed spectra of solutions of known quantities of metallic magnesium. This first photograph appeared to indicate the presence of 1-10,000th of the metal. Three separate solutions were made containing 1, 2, and 3 parts of the mineral in 1,000 volumes of the solution, and these were photographed on one plate. On comparison with the standard photographs, it was found they exactly corresponded to those obtained from solutions containing 1, 2, and 3 parts of magnesium in 100,000 volumes of solution. The mineral therefore contained 1 per cent. of magnesium. The comparison of the photographs was made by three independent observers, who each gave the same figures from the two different series of photographs.

By simple inspection of the first photograph, it was seen that the calcium amounted to something between 30 and 40 per cent. of the mineral. Special precautions are necessary in estimating calcium, on account of the dust flying about in the air always showing the most prominent lines of this metal to a greater or less extent. Gold electrodes were used, and a short exposure in this special case. There appeared to be 37 per cent. of calcium present, because a solution containing 1-10,000th of the mineral yielded a similar spectrum to a solution containing 37 parts of calcium in 10,000.

Five photographs were then taken of each solution, the results may be stated as follows:—

The Mineral. $\frac{1}{10000}$.	The Standard Calcium Solution. $\frac{37}{10000}$.
1. Five seconds exposure.	1. Five seconds exposure.
2. Fifteen ,, ,,	2. Fifteen ,, ,,
3. Thirty ,, ,,	3. Thirty ,, ,,
4. Five ,, ,,	4. Five ,, ,,
5. Fifteen ,, ,,	5. Fifteen ,, ,,

It was not quite clear whether there was any difference between the length and strength of the calcium lines in the first three pairs of photographs, but in the fourth and fifth pairs it was certain that there was no difference, and hence it was concluded that there was 37 per cent. of calcium in the mineral. The mineral was very carefully analysed by the ordinary process and two or three different portions were examined which showed slight differences in composition. The separation of the magnesia was made with all possible care, a correction being made according to the directions of Fresenius for the slight solubility of the ammonia-magnesian phosphate in the filtrate and wash-water. The results are as follows:—

Anaylsis of Amygdaloid Limestone.

By the Spectroscope.

	Per cent.			Per cent.
Mg	1	=	$Mg CO_3$	3·5
Ca	37	=	$Ca CO_3$	92·5
				96·0

By the Gravimetric Method.

	Per cent. (1)	Per cent. (2)		Per cent. (1)	Per cent. (2)
Mg	1·17	1·38	$Mg CO_3$	4·08	4·83
Ca	36·45	36·98	$Ca CO_3$	91·11	92·45
				95·19	97·28

In the second analysis it may be mentioned that the whole of the constituents were found to be those contained in the following statement:—

	(2) Per cent.	Total carbonates.
$Mg Co_3$	4·83	97·28
$Ca CO_3$	92·45	
$Al_2 O_3$ and $Fr_2 O_3$	2·24	
Insoluble residue..	0·82	
	100.34	

The Absorption Spectra of Minerals.—It is well known that many minerals yield solutions having the property of selective absorption of certain parts of the spectrum, and amongst these are the salts of uranium, didymium, and erbium. It is scarcely possible on the present occasion to do more than very briefly allude to this subject, but as the discoveries of samarium and holmium have certainly been established by this method of observation, I cannot altogether omit to mention it.

Several of the absorption bands belonging to the rare earths appear in the violet and ultra-violet region. I am indebted to Professor L. Soret, the first discoverer of holmium, for the beautiful photographs of the spectra of these rare earths which are now exhibited. Interest in this subject cannot fail to be awakened by an examination of these photographs. The lenses used were of quartz, achromatised with fluor-spar, according to the method of M. Cornu.

Solutions of the chlorides of the rare metals show the following characters:—

Erbium.—Four absorption bands lying between L and extending to just beyond N.

Holmium.—Three bands between M and midway between Q and R.

Samarium.—Six bands between G and O, the last band being at O. The chief bands are between G. and H.

Didymium.—Two strong bands between N and O.

The Examination of Organic Substances.

Dr. Miller failed to trace any connection between the chemical complexity of a substance and its actinic absorption. In January, 1878, M. L. Soret published his "Recherches sur l'Absorption des Rayons Ultra-Violet par diverses Substances" ("Archives des Sciences Physiques et Naturelles, Genève," [2] lxi. 322.) This work included the examination of many inorganic and some organic compounds. In 1879, a paper was published in the "Philosophical Transactions" (vol. clxx, p. 257, Part I.), dealing with connection between the absorption spectra and the chemical constitution of organic compounds. Later results have from time to time been presented to the Royal Society and the Chemical Society, a brief notice of which may prove to be of interest.

The ultra-violet rays are exceedingly sensitive to the action of carbon compounds, so much so that the photographic absorption can be employed as a means of identifying organic substances, and as a most delicate test of their purity. The curve obtained by co-ordinating the extent of dilution with the position of the rays of the spectrum absorbed by the solution of a compound forms a strongly marked and often its most highly characteristic physical property.

Organic substances are of these classes:—

1. Those which transmit continuous spectra and are highly diactinic. Examples—The alcohols, acids, ethereal, and haloid salts, and carbohydrates.

2. Those which transmit continuous spectra, but yet possess strong absorptive power. Examples—Most essential oils and camphor.

3. Those which exhibit absorption bands. This class includes benzene, naphthelene, anthracene, and all their derivatives, nearly

all the natural alkaloids, and many substances in which nitrogen and oxygen are united. Cymene, which is a derivative of benzene, has been detected, and even the amount estimated in many essential oils.

All these substances contain a nucleus with the same constitution as that of benzene. The curve obtained from benzene is exhibited. By the process of diluting with alcohol the presence of bodies of the aromatic series have been detected in essential oils, and even in some cases the amount of these substances has been estimated.

The greatest interest attaches to the examination of the alkaloids. Many of these substances are highly poisonous, they give no distinctive chemical reactions by which they may be identified, and the only means of recognising them are their crystalline form and physiological action. Some of the alkaloids have never been crystallised, and even such as are usually obtained in crystals are not always recognisable; moreover, the form and grouping of crystals is occasionally modified by such reactions or treatment as is necessary in the extraction of an organic base. No absolute reliance can be placed upon the mere appearance of crystals which are microscopic; they must be submitted to recrystallisation by sublimation or some other process. The physiological action of certain alkaloids is remarkable enough to prove a means of identifying when the effect on the human subject is under observation; but it is to some extent capable of being modified by the extent of the dose, the administration of other drugs, or the idiosyncrasy of the patient. These are well known and grave objections to experiments of a physiological character which I have not time to discuss at present. The whole subject of the modification of alkaloids by the reagents used in their extraction, variations in their crystalline character and in their physiological action, can be well illustrated by reference to the researches of Dr. C. R. A. Wright, F.R.S., on the various preparations known as aconitine. The evidence given at the trial of George Henry Lamson, a surgeon, at the Central Criminal Court, in 1882, for poisoning by the administration of aconitine, rendered of great importance any method of absolute physical measurement which might take the place of ordinary physiological tests in the identification of the dangerous alkaloids. The forthcoming volume of the "Phil. Trans." for 1886 contains an account of work on this subject, abstracts of which have already been published in the "Proc. Roy. Soc.," (vol. xxxviii, pp. 1 and 191.) About forty authentic specimens of the alkaloids have been examined; I propose to show the absorption curves of many of these substances.

Alkaloids and derivatives exhibiting spectra with absorption bands.

Aconitine.	Diacetylcodëine.
Pseudaconitine.	Quinine.
Japaconitine.	Quinine sulphate.
Morphine.	Cinchonine sulphate.
Narcotine.	Quinidine sulphate.
Codëine.	Cinchonidine sulphate.
Papaverine.	Veratrine.
Oxynarcotine.	Piperine.
Apomorphine hydrochloride.	Brucine.
Tetracetylmorphine.	Strychnine.

The absorption spectra offer so ready and valuable a means of ascertaining the purity and of establishing the identity of the alkaloids, that drugs of such potency as aconitine, morphine, quinine, strychnine, &c., should be submitted to spectroscopic examination, so that their exact nature and degree of purity may be guaranteed before they are prescribed. The differences in character of the various specimens of aconitine are remarkable; the comparatively harmless base is easily distinguished, and of those which are physiologically active, each has its distinctive absorption curve.

The cinchona alkaloids show strikingly distinct curves; so in like manner do those of the papaveraceæ. Two specimens of morphine exhibit the same curve, and so do two of codëine. There is a difference but yet a similarity between the morphine and the codëine, which arises from the constitution of the two bodies being only slightly different, codëine being a methyl-morphine.

DISCUSSION.

The CHAIRMAN said they were much indebted to Professor Hartley for the great trouble he had taken in explaining his interesting experiments. He had worked on this subject for more than twelve years, and might be said to have made it his own, and of its importance there could be no doubt. It was clear that photographic spectroscope observations was in many respects superior to the ordinary eye observations, for here was the actual record taken by nature herself, which might be referred to at any future time. Eye observations, although invaluable in many ways, and in some respects superior to the photographic, could not be so reliable. Professor Hartley had given an interesting historical sketch of what had been done in this way since the year 1842, when Edmund Becquerel first made observations of this character. The question might be regarded from two points of view, the qualitative and quantitative. The efficacy of spectroscopy as a qualitative test had been thoroughly proved by Bunsen and Kirchhoff in 1862; but the quantitative power of spectroscopy was another and perhaps more difficult matter, and of that they had heard a very voluminous account that evening. It was a question of the very greatest importance whether the spectroscope could furnish the means for the quantitative estimation of these bodies which it could detect qualitatively in such minute amount. The experiments now brought forward seemed to show that, at any rate, there was good ground for believing that such an estimate could be made; and this was exhibited both in the diagrams and in the interesting analyses of zinc ore and amygdaloid limestone. How far this method could be carried time would show. It might be that each investigator would have to make a series of quantitative spectra for himself, similar to those shown on the diagrams. For instance, each particular instrument might show either different lines or the same lines with different intensities; and, therefore, he took it that for quantitative analysis of metals, each observer would have to work from the beginning himself; but this would not interfere seriously with the value of the method. There was still a great deal to be learned in this matter, even with regard to qualitative tests. For instance, he was not aware of any experiments showing the limiting amount of nitrogen which could be detected in a large excess of oxygen, or *vice-versâ*. Although they knew that the spectroscopic tests were very delicate, he did not think the limits of that delicacy had yet been fixed in many instances, and there was still a wide scope for experiment in that direction. He was much interested in the curves representing absorption spectra of the alkaloids, but should be glad if the spectra themselves could be shown, as a better idea of the results was given in that way. We must, however, not imagine that the spectroscope can ever altogether supplant the older and more laborious methods of chemical analysis. As an instance of this he would refer to some experiments of his own, brought, many years ago, before the Royal Society of Dublin, in Mr. Hartley's presence, relating to the question of identification of lines which were supposed at one time to be common to several metals. Thus it was believed that certain lines in thallium and in zinc were identical in position with certain lines of lead. On examining samples of the purest thallium and purest zinc obtainable, it was proved that a line appearing in the spectra of those two metals also appeared in that of lead, and the question arose, was this a lead line? Was lead contained as an impurity in the two metals in question, or was the line due to some common constituent in the three metals hitherto unrecognised? Experiment showed that the line found in the thallium and in the zinc was in reality a lead line, but in determining that question chemical means had to be called to aid for the purpose of proving that lead really did occur in this so-called pure thallium and zinc. The ordinary chemical tests for lead were obtained from both of the above metals. Hence chemists might still uphold their old methods of examination, which would always be employed to control and verify the results obtained by the spectroscope. At the same time the information they had already received, and were likely to receive, from researches like those of Professor Hartley must be welcomed as a most important addition to their knowledge.

Dr. Gladstone, F.R.S., desired to support most cordially the remarks made by the Chairman as to the value of this communication, and of this adjunct to the methods of chemical analysis. Being acquainted with Professor Hartley's published papers on this subject, he could speak to the great care and assiduity that had been bestowed upon it. Professor Hartley had brought forward two ways in which photography could help analysis, one being the examination of spark spectra, and the other of absorption spectra. The spark spectra were very curious and interesting, and Mr. Hartley had shown that they could be applied to a certain extent quantitatively, and would sometimes give indications which could not be obtained by means of ordinary chemical tests. At the same time, these spark spectra always seemed to him to be rather tantalising. We wanted to know why there was such a number of rays coming from different substances, and we ought to be able to generalise in some way, and classify these bodies. At present there were no indications given of the constitution of the bodies by means of these spark spectra, but it was quite possible that further investigation in this direction might throw a flood of light on the composition or mutual relations of the various elementary bodies. In the case of absorption spectra the information was, perhaps, of a still more valuable order. First of all, they gave a vast amount of new information with regard to the bodies themselves, comparable to the information conveyed to the eye in the form of colour by means of a prism. Beyond that Mr. Hartley had been able sometimes to detect substances in small quantities in the presence of other bodies, for instance cymene in certain essential oils. It was supposed that the oils of orange, of lemon, and so on, contained a very considerable amount of cymene, and this was a matter of important discussion amongst chemists, but Mr. Hartley, by bringing this method of analysis to bear, decided the matter absolutely, and showed that they did not contain cymene as a necessary constituent, but that some of them did contain a small quantity. Beyond that he had been able to make certain generalisations as to the distinction which existed between those bodies which exhibit in continuous spectra, those which show absorption bands but are highly diactinic, and those which manifest strong absorptive power. These differences followed certain chemical views as to the constitution of those bodies. Investigations in the same direction, on the same substances, had been made in other ways by the refractometer on the refraction and dispersion of these bodies, and, as far as the speaker had been able to ascertain, the results agreed with those arrived at by Mr. Hartley, both with regard to specific refraction and specific dispersion. At the same time Captain Abney had been making some observations on the absorption at the red end of the spectrum, and though they were but few in number, as far as they went they also corroborated the conclusions derived from these photographic experiments. He trusted Mr. Hartley would be encouraged to go on making further investigations in this direction.

Professor HUNTINGTON said it was now some five or six years since he had worked on this subject with Professor Hartley, and he had therefore somewhat lost touch of it, but he had been much interested in the paper. At that time it naturally occurred to them that this method might be available as an adjunct in the detection of alkaloids in poisoning cases; but, if he remembered rightly, one of the difficulties in the way was that of eliminating the colouring matter associated with any matter found in the body, and he should like to hear from Professor Hartley whether any further progress had been made in overcoming that drawback. There was no doubt that even then very minute quantities—in one case, one part in a million—was perfectly recognisable, but that was in a colourless solution, such as alcohol or water. In the case of coloured solutions the spectrum was cut off entirely from the more refrangible end, and all the absorption region was lost. Mr. Hartley had brought forward some very interesting facts with regard to the quantitative determination of the constituents of alloys, but he could not help agreeing with his remark that, so far, the ordinary assay was more reliable. Still, of course, this process was but in its infancy, and possibly in the course of time more would be done. One of the principal difficulties which presented itself to his mind was the getting a perfectly reliable comparison between the standard adopted and the photographs taken at different times. It involved getting always exactly similar conditions as to the intensity of the spark, and so on, and though that of course was possible, it presented certain difficulties.

Professor HARTLEY, in reply, said he did not believe the spectroscope would ever be of any value if it were dissociated from chemical methods. It was not the slightest value to take a solution of a mineral just as it was made and to spectroscope that solution. For instance, in the case of the blende, the analysis of which he had tabulated, to spectroscope the solution of it without first separating the zinc or the other metals from the zinc would give very little result indeed. It would indicate the presence of lead and the presence of zinc, but you could do that by ordinary methods quite as easily if not more so. But if you separated the chief constituents from the minute constituents, and spectroscoped the solution of the minute constituents, or the bead of metal which could be obtained containing them, then you had a very valuable method, because operating on quantities which were at all manageable no results worth speaking of would be obtained by the ordinary method, whereas by the spectroscopic method very valuable results were obtainable. It was frequently of greater importance to know approximately the amount of the minute constituents of a substance within certain limits, rather than to know with very great accuracy the amount of those minute constituents. This was especially the case when you could obtain, in the course of an hour or so, a distinct set of quantitative results, which you could not obtain by the ordinary modes. This was a point which would be fully recognised only after a good deal of work had been done by this method. The estimation of the magnesium in limestone and such minerals could be made more accurately and rapidly by an instrument of this kind than by any other method. With regard to the colour of solutions of organic substances, he had simply to say that, up to the present time, it had been impossible for him to devote any attention to the detection of alkaloids or poisons of any kind which had passed through the body. He had only been able to investigate pure authentic specimens; impure substances would be of no use whatever in the researches he had made. The investigation of substances which had passed through the body, or had been extracted from organic matter—and therefore had been submitted to the colouring action of other bodies—had yet to be tried. He had, however, succeeded in decolorising some alkaloids which had been coloured without altering their absorption spectrum, which was rather an important point. It had, however, only been done in a few cases, and might not be generally applicable. With regard to the variation which might occur in the spark when fitted with different electrodes, or when taking photographs from solutions passing from a carbon electrode to a metallic electrode, he could not say that there was any difficulty in obtaining a spark of constant intensity. With a Grove battery, or any battery set up for the purpose, under ordinary circumstances, there were difficulties; in the course of working, the electromotive force ran down considerably, sometimes when one least expected it, and the results then obtained at one hour were not comparable with those obtained at another; but working with storage batteries, the difficulty was very much less, and, in point of fact, in his observations no such accidental difficulties produced any sensible effect. If you were photographing from an alloy of a known composition, the spectrum obtained on one day, or one part of a day, would correspond accurately with the spectrum from the same alloy taken at any other time. At the same time, you must work under the same conditions; you must employ the same coil, and the same condenser, or the same condenser and another coil, but the battery power, the coil, and the condenser, must be so proportioned as to give a constant stream of sparks. Very little experience, however, taught one when the spark was passing properly, and there was not the slightest difficulty in making this due proportion between battery power and the power of the coil, and the distance between the electrodes, which also comes into play. If you employed a condenser, such as the one on the table, containing on each face 72 sq. in. of tinfoil, a very good result was obtained. With a spark of convenient length and sufficient brightness, and with exposures usual with lenses of a certain focal length, you always got the same result. In point of fact, the photographs obtained from an alloy of lead and cadmium, 25 per cent. cadmium, by the side of another alloy of tin and cadmium containing 25 per cent. of cadmium, had been examined by himself and his assistants to the number of several thousands, and he had never seen any variation in those lines, excepting in cases where the photographs were done by an inexperienced assistant, who did not adjust the spark and the lens so as to transmit the rays directly through the collimator tube; under those circumstances a very weak spectrum was obtained, so weak that one saw at a glance there was something wrong. This was a proof that accidental variations were so slight, that with the ordinary exposure they did not affect the results. He would conclude by throwing on the screen a few absorption spectra, showing the great difference in the amount of absorption which took place, according to the thickness of layer of the solution.

The CHAIRMAN then proposed a vote of thanks to Professor Hartley, which was carried unanimously.

FOURTEENTH ORDINARY MEETING.

Wednesday, March 10, 1886; Lord RAYLEIGH, M.A., D.C.L., F.R.S., Secretary to the Royal Society, in the chair.

The following candidates were proposed for election as members of the Society:—

Aitkin, Charles Edmund, M.R.C.S., 7, Clifton-place, Sussex-square, W.
Breen, George, 204, St. Vincent-street, Glasgow.
Burdett-Coutts, William, M.P., 1, Stratton-st., W.
Stein, Cecil, 42, Ladbroke-square, W.
Symons, Henry, J.P., Totnes, Devon.

The following candidates were balloted for and duly elected members of the Society:—

Adderley, Augustus J., C.M.G., Davenport, Bridgnorth.
Doxford, William Theodore, Grindon-hall, Sunderland.
Lydall, William Hawthorne, 60A, Watling-street, E.C.
Parry, Sidney Gambier, 3, Clareville-grove, South Kensington, S.W.
Steel, Robert Elliot, M.A., Spring Clifte-house, Heaton-road, Bradford.
Thorpe, Thomas Wells, Albion Brewery, Whitechapel, E.

The paper read was—

THE EXPERIMENTS WITH LIGHTHOUSE ILLUMINANTS AT THE SOUTH FORELAND.

BY E. PRICE EDWARDS.

Before entering upon a description of the experiments with lighthouse illuminants which were carried out at the South Foreland in 1884-5, I think it proper to state that it would be out of place, on the present occasion, to refer to any personal considerations which may have been connected with the question of setting these trials on foot, therefore I shall address myself solely to the practical view of the subject, and endeavour to present to you, from my own knowledge, a dispassionate and impartial account of these important experiments, and put before you the conclusions which may be legitimately drawn from them.

For the benefit of those not technically acquainted with the details of lighthouse illumination, I must make some preliminary observations of a general character.

For very many years the illumination of lighthouses has been an attractive subject for the efforts of earnest inventors, and the suggestions of fanciful speculators. I will not detain you with a recital of the numerous schemes which, from time to time, have been put forward, but will at once tell you that the only illuminating agents which have successfully borne the tests of experiment and experience, and have been found to be serviceable for lighthouse purposes, are oil, gas, and electricity. The cardinal principle in connection with the maintenance of our coast lights is certainty; there must be no breakdown of the lights between sunset and sunrise. Mariners approaching our shores at night from distant parts are almost entirely dependent upon their sure and effective exhibition. Each one must be readily and certainly recognisable, in accordance with the advertised intimations of its special characteristic. In fulfilment of this essential condition it has come to pass, by a process analogous to that of the survival of the fittest, that oil, gas, and electricity remain the only sources of light upon which complete dependence may be placed for the purposes of effective lighthouse illumination.

In continuation of these preliminary remarks it will be useful to consider the general subject under three headings :—

1. The actual sources of light.
2. The mechanical means by which the light is sustained and controlled.
3. The appliances for utilising the light produced in the manner most serviceable to the mariner.

As each of the above named divisions would, in itself, afford ample material for a paper, I must ask you to forgive my touching them with a light hand only. My object will be simply to give those of my hearers to whom the subject is unfamiliar some general notions which will make the latter portions of my remarks more intelligible to them, and to connect the general principles of lighthouse science with the investigation at South Foreland.

1.—SOURCES OF LIGHT.

Oil.—Regarding these three illuminants as mere sources of light without reference to burners, lenses, or any of the appliances ordinarily used in lighthouses, we will first give our attention to oil, which is the oldest of the three, its use dating back for nearly 100 years, when it began to replace the coal fire and candle systems of the last century. For the greater part of this long period sperm oil was used, but in 1845 it was demonstrated that rape seed or colza oil could be burned as effectually, and at much less cost, and the use of sperm was discontinued. In modern times mineral oil has come to the front, and threatens to supplant the vegetable oil entirely, being very much cheaper, and giving an illuminating effect almost, if not quite, equal to that of rape oil. The latter is, however, still employed at isolated rock lighthouses and on board lightships, chiefly for considerations of safety. The mineral oil now used in this country is paraffin obtained by the distillation of shale, and is at present supplied with a flashing point of 154° Fahr., thus rendering it a perfectly safe oil for use in this climate. Quite recently, a mineral oil, having a flashing point above 250° Fahr., has been tested with most encouraging results, which, if corroborated by further tests, will make it very suitable for rock lighthouses and lightships, and will tend to shut out rape oil altogether, the latter being fully twice the price of the new product. It is a coincidence that vegetable should displace animal oil, and that mineral should now be about to supplant vegetable oil. With some few exceptions, which will be referred to in dealing with gas and electricity, oil is the general illuminant now used in lighthouses of the United Kingdom, as well as in all parts of the world. In this country rigorous tests are applied to ensure the oil sent to lighthouses being of the very finest quality. Both rape and paraffin must burn without requiring to be trimmed for 16 hours. Careful examination of each is made, to ascertain if any acid is left in, or other deleterious compound mixed with either kind of oil. The requirements in respect of the paraffin now used are that it must have a specific gravity between ·810 and ·820 at 60° Fahr., with a minimum flashing point of 140° Fahr. (close test), and must distil between the temperatures of 302° and 572° Fahr. The conjunction of such qualities as are indicated by the above requirements provides an effective and in other respects suitable oil for burning in lighthouses.

So far as the experiments at the South Foreland are concerned, rape oil need not be taken into consideration. Paraffin of the description above referred to only was used, and may be regarded as the representative of the oil system.

An important point may perhaps be here appropriately referred to in connection with the cost of lighthouse oil. In the early stages of the discussion as to the relative advantages of gas and oil, about twelve or fifteen years ago, economical arguments in favour of gas were based on the then prices of rape oil, which were variously quoted as 4s. 9½d., 3s. 10½d., 2s. 9d. per gallon. In these days paraffin is supplied at 6d. per gallon, a fact which obviously changes the financial aspect of the comparison very considerably.

Gas.—In the year 1865, Messrs. Edmundson and Co., of Dublin, of which firm Mr. J. R. Wigham is an enlightened and enterprising member, perfected a system by which gas could be employed as a lighthouse illuminant. At first, gas made from oil was employed; but subsequently cannel coal gas was adopted. This illuminant was first established at the Howth Bailey Lighthouse, shortly afterwards taken to that at Wicklow Head, and subsequently extended to seven other lighthouse stations in Ireland, and one in England.

The gas used is obtained, by the usual process of manufacture, from the best cannel coal, and gives an illuminating power much higher than that of gas made from ordinary north country coal, such as is used in gas works of towns where a large supply is required to be distributed. Burned in the London standard Argand burner, the gas from north country coal does not give a light superior to that of sixteen candles, as required by Act of Parliament; whereas the gas made from good cannel coal, when burned in the London standard burner, yields a light almost equivalent to that of about thirty candles. For lighthouse purposes it is essential to have the best light, and therefore cannel gas has been exclusively employed, although much dearer than north country coal. The average price of cannel delivered at the lighthouses appears to range between 40s. and 50s. per ton. A quantity of furnace coal, about one-half that of the cannel carbonised in the retorts, is required for each gas works, and the whole manufacture has to be carried on at the lighthouse station. The cannel coal used at the South Foreland was chosen by Mr. Wigham as best adapted for the experimental gas light to be exhibited, and came from the Lesmahagow pit.

In addition to the use of cannel gas, trials were also made at South Foreland with gas obtained from mineral oil, which proved to possess an illuminating power equal to that of 46 to 50 candles. The gas-making apparatus was put up at South Foreland by Pintsch's Patent Lighting Company, as exemplifying their system of making gas, which is of a simpler character than that of cannel gas. The works are smaller, and consequently cheaper, and the operation of gas-making can be carried out by one man alone. The oil used is paraffin, not refined, and is supplied at South Foreland at about 6d. per gallon, but would be cheaper delivered in London. The oil is caused to drip on to a tray placed in the retort, where it is heated sufficiently to convert it into gas, which, after passing through some purifying operations, goes into the gasholder. As compared with cannel gas, the higher illuminating power of Pintsch's oil gas, in conjunction with the comparative simplicity of manufacture and economy of gas-making plant, all point to its probable superiority for lighthouse purposes. The data at my disposal are not sufficient to enable me to say with certainty whether the cost per 1,000 cubic feet is less than that of an equal quantity of cannel gas, but even assuming the price to be the same in both cases, the higher illuminating power of Pintsch's gas would make it at least 25 per cent. more valuable as an illuminating agent.

During the trials at South Foreland, the bulk of the comparisons were made with cannel gas, and a small proportion only with Pintsch's oil gas.

Electricity. — The next division of our sources of light has reference to electricity. This illuminant has been employed with success in certain lighthouses in this country since 1862. In France it was first used in 1863, but of late years it has received a very considerable impetus in that country. The limited application of this luminary in the United Kingdom is not due to any practical difficulties in respect of its installation, but rather to a dislike on the part of mariners of its extremely dazzling and distressing light when they are close to it. The navigable channels leading to and from our ports and harbours are mostly near land, and are often crowded with shipping; a very dazzling light shining across the navigation at such a place would be likely to prove a source of danger rather than of safety. Chiefly on this account electricity has made but slow progress as a lighthouse illuminant in this country.

In 1857, the discovery by Faraday of magnetic induction in a coil of copper wire, was turned to practical account for lighthouse illumination by Professor F. H. Holmes, who then made the first complete magneto-electric machine. In that year trials with the newly born electric light were commenced at South Foreland, and were continued until 1859. Then it was discontinued at South Foreland, but established at Dungeness lighthouse in 1862. After some further experience, a new lighthouse on Souter Point Coast of Durham was lighted up with the electric spark, and in 1872 it was brought back as a permanency to its first home at South Foreland, and has shone there successfully ever since. In 1874, it was removed from Dungeness, because the point was low and dangerous, and mariners did not like the light in their eyes, and could not judge their distance from the point. In 1877, it was taken to the Lizard lighthouse. It is now intended to show electric light from the lighthouse on St. Catherine's Point, Isle of Wight, and from the High Tower on the Isle of May, Frith of Forth.

The machines originally employed for generating the necessary electrical energy were constructed on the magneto-electric principle, which necessitate the use of permanent magnets for the induction of electricity. I have mentioned that Holmes made the first machine on this principle, and Holmes's machines are at present employed, after running fourteen years, in maintaining the lights shown from the permanent lighthouses at South Foreland. In 1876, some trials were made with various electric generators, to ascertain which kind of machine was most suitable for producing the electric light for lighthouses. The verdict was in favour of Siemens's dynamo machines, and accordingly these machines were adopted for the Lizard Station in 1877.

In consequence of some serious irregularities in the working of these machines, and because at the time Baron de Meritens, of Paris, had perfected a very powerful and, in some respects novel, form of magneto-electric machine, it was resolved to send one of these new generators to the Lizard, where it has worked most satisfactorily for several years. The experience gained at Lizard suggested that for the St. Catherine's station, which it had been resolved to illuminate with electricity, the De Meritens machines should be employed, and they were accordingly ordered; but as arrangements were then being made for the South Foreland experiments, it was agreed that these machines should be sent direct to South Foreland, to be used in the trials, and to be operated by the steam-engines already established there, there being a reserve power beyond what was required for the permanent electric lights. The De Meritens machine consists of five star-like rings, fixed parallel to and a little distance from each other. Each ring carries twelve permanent magnets of horse-shoe pattern, with their poles, converging towards a central horizontal shaft. Upon the shaft are mounted five brass wheels or discs, which revolve within and in front of the poles of the magnets. Each wheel carries twenty-four helices or coils on its periphery, and one revolution causes the twenty-four coils of each disc to pass the twenty-four poles of the twelve magnets in each ring, thus producing alternate currents of positive and negative electricity. The machine is worked at a speed of 600 revolutions per minute, and the result may be popularly stated thus—

Coils. Poles. Rings. Revol·
24 × 24 × 5 × 600 = 1,728,000 pulsations of alternate electricity generated in one minute. The electrical energy so excited is taken off by collectors at the ends of the shaft, and conducted by leads to the lighthouse lantern. At the South Foreland the distance between the generating machines in the engine-room and the electric light lantern was 850 feet, and Professor W. Grylls Adams has shown that one-third of the united energy developed was expended in overcoming the resistance of this great length of conducting wire. Had the generating machines been close to the lantern, the electric light exhibited would have been reinforced by one-third more electrical energy than actually reached it. As a matter of fact, these machines were made for the St. Catherines Station, where they will be only a very short distance from the lighthouse.

During the trials the machines were worked either singly or coupled up with two machines in series, and occasionally with three machines in quantity. The lights shown were produced by either—

One machine with an average current of 125 ampères, and E.M.F. of 51 volts.

Two machines in quantity for one arc light, with an average current of 176 ampères, and E.M.F. of 60 volts.

Two machines in series for one arc light, with an average current of 182 ampères, and E.M.F. of 60 volts.

Three machines in quantity for one arc light, with an average current of 180 ampères, and E.M.F. of 60 volts.

The three machines could not be coupled up in series, and the result of their being coupled in quantity is not so good as the two machines in series, which gave a current of 182 ampères. The high resistance with the three machines was due to the fact that the leads were not suitable for the current from three machines. It will be seen that the most effective results were obtained with two machines coupled in series feeding one arc light.

II.—THE MECHANICAL MEANS BY WHICH THE ILLUMINANT, WHEN PRODUCED, IS SUSTAINED AND CONTROLLED.

In the case of oil this important function is performed by the burner. I shall not occupy your time by giving a historical account of the development of the oil burner from ancient days, but a few observations on the general principles upon which oil burners for lighthouses are constructed may perhaps be acceptable.

It is tolerably well-known that when oil is consumed in a lamp, it is converted into vapour by heat, and that the oil vapour so produced is, by the application of flame, caused to combine chemically with the oxygen in the surrounding atmosphere. In point of fact, an oil burner is analogous to a miniature gas-works, where the gas is consumed as fast as it is manufactured. An ordinary mineral oil burner is connected with a reservoir containing oil below it by means of a cotton wick, the lower end of which is in direct contact with the oil, the upper end just above the top of the burner. By capillary action the oil creeps upward until all the wick is saturated up to the point where the oil is to be converted into vapour, the application of flame only being required to complete vaporisation and set it burning. The supply of oil must be properly regulated. With heavy fatty oils, such as rape or sperm, the capillary action is not vigorous enough to bring up from a receptacle below a sufficient quantity to keep the light going, and in that case the actual level of the oil immersing the wick must be close to the burning point. With mineral oil the level may be two or three inches below the burning point, and its capillarity will be sufficiently active to conduct it to the top. In the case of large lighthouse lamps the main reservoir is kept at a considerable distance below the burner, and mechanical means are employed to force the oil up to the required level, and to keep it constant for either a heavy or a light oil. To make combustion perfect, and to prevent smoke and soot, a plentiful and well-regulated supply of oxygen is essential. In the latter part of the last century, Argand demonstrated practically how such a supply could be secured for a single circular-wicked lamp, and the principle then laid down has ever since been followed in the development of the construction of lamps for burning oil. In this Argand burner you see a central tube, to which air has access at the bottom; the wick surrounds this tube, and in burning gives a circular flame, fed by the air coming up the centre. The glass chimney on the outside regulates the admission of air to the outside of the ring of flame, and thus perfect combustion is effected. A further development of the principle was made by Fresnel, who produced a burner consisting of four concentric wicks, with an air space separating each wick case, and the large glass chimney enclosing the flame completed the arrangement. Sir James Douglass increased the number of rings by two, producing the six-wick burner, which is now, and has for many years been used in many Englsh lighthouses, and was the representative oil burner employed in the South Foreland experiments. It should, however, be mentioned that Sir James Douglass had proceeded still further, and had produced seven, eight, and nine-wick burners, constructed on an improved principle, by which the flames are compressed at the focal plane, so that their diameter is not much greater than that of the six-wick burner, while the intensity of the light is considerably enhanced. These burners were not sufficiently perfected when the experiments began, and the bulk of the comparisons were therefore made with the six-wick burner. But they now are brought into good working order, and there is every reason to believe they will, before very long, be adopted for lighthouse work, and their increased efficiency will add much to the effectiveness of the lighthouses where they are employed.

In connection with this part of the subject it is necessary to bear in mind that oil burners require careful looking after, that glass cylinders are a necessity, and that wicks of unusual size and very superior quality have to be provided.

For burning gas, the arrangements are certainly more simple. The gas is led by pipes to the burner in the ordinary way, a cock is turned on, and the gas lighted. It then burns without requiring serious attention as long as the gas supply lasts; it requires no glass cylinders nor wicks, no trimming, and little cleaning, all of which are points in favour of the gas system. The gas burners used in lighthouses, and as exhibited at the South Foreland, are those of Mr. Wigham's patent. In its complete form the burner consists of five rings of gas jets, the innermost ring having 28, the next 48, the next 68, the next 88, and the outermost 108 jets, the diameter of each ring being respectively 4, 6½, 8½, 9½, and 11¼ inches. With the gas burning, this congregation of jets packed in the space of a circle 11¼ inches in diameter gives a flame of considerable intensity, to which the air has perfectly free access, there being no glass chimney surrounding it, as in the case of an oil light. This huge flame is controlled in great measure by the draught of the flue, the lower part of which is of talc, and, with the latest improvements as developed during the trials at South Foreland, terminating in a sharp frustum of an inverted cone, and into the lower opening of which the tongues of flame rush in, leaving naked the thickest and most intense portion. This tends to preserve the flame in a uniform shape, which object is also materially assisted by a further improvement, introduced during the trials, of a talc collar fixed upon a collar of perforated zinc, encircling the lower part of the burner. Air passes through the perforations on to the outer surfaces of the flame, and, besides assisting to control the shape of the flame, renders combustion of the gas more vigorous. The reason for employing talc is because it is transparent, and allows a good deal of light to pass through, and strengthen the general illuminating effect, which would be lost if the cases and collars were made of an opaque material. From the blaze of 108 jets, the flame can readily be reduced to that of either 88, 68, 48, or 28 jets. The facility with which this can be accomplished is unquestionably one of the merits of this Wigham gas-burner, the mercury joint for each segment being a specially ingenious arrangement.

Two well-known gas-burners were sent for trial at South Foreland, one the patent 6-ring burner of Mr. Sugg, the other a large size Siemens' regenerative burner. So far as the working of these burners under ordinary conditions is concerned, there is no fault to find with them, but as they proved to be unsuitable for lighthouse purposes, I need not dwell upon them.

Sir James Douglass's 6 and 10 ring gas burners, constructed on principles similar to those of his improved oil burners before described, gave results so satisfactory in the trials, that they must not be passed by. Instead of from jets, as used by Mr. Wigham, the gas issues from surface holes in concentric rings, and each ring forms a complete cylinder of flame, fed on both sides by the air ascending the spaces separating the rings. As in the oil burners, the rings of flame are compressed to the smallest diameter possible at the focal plane. No talc cone or collar is required for Sir James Douglass's burner, but a glass cylinder is necessary to preserve the shape of the flame, by regulating the air supply to the external surface of the outermost ring of the flame.

We now come to the arrangements for the electric light. Assuming the requisite current to be brought with uniform steadiness to the lighthouse lantern, by suitable conducting wires or leads, the regulation and control of the arc light produced between two carbon terminals are mainly dependent upon the action of the lamp or regulator, the delicate and ingenious mechanism of which keeps the carbon points as nearly as possible the same distance apart. The carbons originally used were supplied by Baron de Meritens, and were square in section, made up of a number of smaller square carbons, the entire bundle being 40 m.m. square. The heat caused the metallic bands by which the carbons were bound together to melt, and the consequence was that the small carbons frequently fell out while the light was being exhibited. Other carbons, circular in section, and solid throughout, 30 and 40 m.m. in diameter, were also tried; but those which gave the best results in the trials, and were used most frequently, were the Berlin core carbons, supplied by Messrs. Siemens, 40 m.m. in diameter, and with a core of graphite running through the centre. With alternating currents the electric arc can generally be maintained with a fair amount of steadiness with carbons that are tolerably homogeneous in their composition, but there is always a liability to momentary fluctuations, caused perhaps by the current seeking to make its exit by the direction of least resistance, and thus selecting the weakest parts of the carbon. The incandescence is thus liable to be transferred from side to side, and this gives rise to the appearance of momentary fluctuations. This, however, has not been found to be a very serious drawback on the whole; indeed, in one sense, it may be advantageous, as conferring a marked individuality upon the electric light, enabling it to be more easily recognised. The Berlin carbons, with their graphite core, were found to burn with exceptional steadiness, possibly because the centre core affords the current an easier and consequently more regular course.

It may be mentioned that some 50 m.m. carbons were burnt in the engine-room close to the generators, with the full current of two machines in quantity without loss; the result being a current of 400 ampères with a low E.M.F. of 45 volts only.

Before proceeding to the consideration of the third division of the subject, it is desirable to make reference to what is known as the superposing system of lights. This was first introduced by Mr. Wigham, in connection with his gas system, by placing in a lighthouse lantern two, three, or four burners vertically over each other, with a distance of three or four feet between them. By this means a column of light of great power is obtained, which it was supposed would rival the strongest electric light, and thoroughly eclipse oil. Without reference to any patent right in connection with this matter, which is not only beside the question of the relative merits of the illuminants, but has, I believe, been completely disposed of since the point was brought forward, the question naturally arose—can this method of piling up lights be applied equally well to electricity and oil? No doubt at all existed as to electricity, but as regards mineral oil, it was feared that its tendency to give off inflammable vapour at high temperatures would prevent the placing of such lights at short distances above one another, as the oil might become dangerously heated. Sir James Douglass, however, effectually disposed of any doubt on the subject by putting up three mineral oil burners one above the other, in the oil lantern, at South Foreland, each lamp being fed from one reservoir placed below the floor of the lantern, and the oil being, by suitable pressure and regulation, forced up the respective burners by pipes, and maintained at the necessary constant level. It is important to note that only three oil burners were superposed, while four gas burners were superposed in an equal vertical space. This will show that the oil burners were separated by greater distances than the gas lights were. The iron chimneys which carry off products of combustion and regulate draught in the case of the oil lights were cased with asbestos cloth and silicated cotton wool, to check radiation of heat from the iron surfaces; thus the heat was kept down very successfully in this lantern, and from the experienced gained at South Foreland there is no doubt that four oil lights could have been as safely maintained as three. The electric lights were also arranged to be superposed, but with three lights only, as with the oil lanterns. The terms used for describing the different order of superposition, are biform, triform, and quadriform, representing the superposition of two, three and four lights respectively. It is not necessary to enter into further details concerning this method, but future references to biform, triform, and quadriform will now be intelligible to those who have not been familiar with the subject.

III.—The Appliances for utilising the issuing Rays in the manner most serviceable to the Mariner.

I must again ask the indulgence of the audience in dealing with this part of my paper. Of necessity I must trouble you with some further elementary details, in order to make the whole matter clear.

With any of the illuminants of which I have spoken, burning under the most favourable conditions, and radiating light in all directions, it is clear that some provision must be made for using the issuing rays to the greatest advantage for the purpose required. The light is wanted by the sailor to shine upon the sea; but many rays, if they followed their ordinary course, would go up into the sky; many others would fall on the floor of the lantern. In the case of a lighthouse on shore, many rays would, under ordinary circumstances, go landward. In none of these directions is light wanted to be sent for the sailor's benefit. It has, therefore, been necessary to devise a method of utilising such diverging rays. At first this was accomplished by metallic reflectors, and a considerable amount of success was and is still attained by this method. I need not enter into details respecting the principles of reflection; the subject is too well known. But in 1821, the celebrated Augustin Fresnel perfected an arrangement of glass lenses which, with a single large burner, accomplished the object in view much more effectively and conveniently than with a number of small burners with reflectors. Fresnel, in conjunction with Arago, had invented an oil burner with four concentric wicks, the diameter of the flame being 3⅜ inches. This, however, he placed in the centre of a system of lenses and prisms built up at the proper focal distance around it, so that nearly all the light rays emitted were received upon some part or other of the inner surface of the lenticular structure, the lenses and prisms being so adjusted that, by the well understood action of refraction, the rays were caused to issue from the other side of the glass in a consolidated beam, illuminating only the sea area between the distant horizon and the near shore.

For a fixed light required to show continuously with equal effect over a given arc or circle, vertical condensation only is requisite, the rays being allowed to diverge horizontally without restriction. For this purpose a central refracting belt is employed, with rows of totally reflecting prisms above and below running parallel to it. The proper adjustment of this apparatus causes a beam to issue which illuminates the sea area within the horizon in a constant manner.

For a revolving or flashing light it is

necessary to cut up this all round continuous beam into segments. As before, the rays must be condensed vertically, but in addition they must be condensed horizontally in bundles, leaving dark spaces between. In this case the apparatus is polygonal, and a condensed beam issues from each side or panel. Instead of a lenticular belt all round, each panel has an annular lens with concentric refractors. All the rays falling upon the inner surface of this lens are refracted, and issue as a condensed and independent beam for each panel. The upper and lower prisms in each panel are curved so as to coincide with the concentricity of the central lens. The rays being squeezed or condensed into bundles, dark spaces are left between them. On the whole glass apparatus being made to revolve, beams of light striking the sea area within the horizon, followed by intervals of darkness, succeed each other with regularity.

The flame of Fresnel's 4-wick burner is the basis of our present dioptric system. Six orders of lights were instituted in Fresnel's time, the first order being specially adapted to the dimensions of the 4-wick flame, so that the lenticular instrument should receive all the rays emitted from such a flame. For second order lights, the dimensions of the flame of a 3-wick lamp determined the radius, focal distance, &c., of the lenses employed, and so on. But since that time the 6-wick burner has come into use, 7, 8, and 9-wick burners are on the threshold, and nearly all Mr. Wigham's gas burners, as well as those of Sir James Douglass, have larger flames than Fresnel's 4-wick oil burner. Again, the electric light, with a smaller luminous centre than Fresnel ever contemplated for a lighthouse illuminant, has come into action, so that, in point of fact, the orders of apparatus as established by Fresnel, are not adapted to the large and small flames used at the present day. This anomaly is in a fair way of being set right, for Messrs. Stevenson, the eminent lighthouse engineers of Edinburgh, have recently designed a lens of larger radius adapted to an illuminant of increased diameter, and have obtained some striking results with a single Douglass 10-ring gas burner against biform 108 jets.

It remains for me now to explain to you what were the lenticular arrangements employed to give the best results for each lighting system tested at South Foreland. It will be understood from what I have previously said, that besides the single light of each system, provision was made for showing the electric light in biform and triform arrangement; that gas could be exhibited in biform, triform, or quadriform; and that oil was provided to show biform and triform only. Consequently, for the electric and oil lights three sets of lenses were required to be mounted in each lantern, and for the gas light four sets were necessary. By the term sets of lenses, I mean one lens arrangement for exemplifying a fixed light, the other for showing the condensed beam of a revolving light. Lenses being very costly articles, it was necessary to have a certain regard to economy, consistent with an effective illustration of the value of lenses in connection with the lights to be exhibited Therefore, one panel only of a fixed belt, and one annular lens of a revolving apparatus, without upper and lower prisms in any case, were provided for each light of each system, the quality of the light issuing from a portion of the apparatus being exactly the same as though the entire apparatus were employed, the only essential point being, that in judging the value of the light, the observer should take care that he is in the path of the beam.

The three towers which were erected at South Foreland for the exemplification of the three systems, were 180 feet apart, and marked respectively A, B, and C. A was appropriated for the electric light; B for the gas system as developed by Mr. Wighan; and C for the oil system and the Douglass gas burners.

In lantern A there were three electric lamps on three stages, and for each lamp was provided a panel of a fixed apparatus of the second order, consisting of a segment of the central belt with seven smaller segments above it and seven below it. The chief reason for using the second order apparatus appears to be that, as Sir J. Douglass practically observes, it affords just enough space for a fairly fat light-keeper to get inside and manipulate the lamps. A third, or even further order apparatus, would have been sufficient, although the luminous area has considerably increased, since the early days of the electric light, where carbons of small sections were used. For exemplifying the revolving beam, an exactly similar panel was used for each light to condense the rays vertically, and in addition four vertical refracting prisms were fixed on the outside of this panel, and caused to issue a condensed beam of great power. It may here be mentioned that, as the divergence of this beam horizontally was very small (30° condensed to 5°), it was necessary to take precautions to ensure observers being in its path. In the superposed arrangement the distance separating the three lights was 7 feet, and the space between the lenses 4 feet.

In lantern B the four lights had each panels for exemplifying a fixed and revolving light. For the former, each light was furnished with a segment of the lenticular belt of a first order apparatus without upper and lower prisms. For the revolving light, four first order lenses of annular construction were supplied, each subtending a horizontal angle of 60°. The beautiful lenses of French manufacture were very considerately lent for use in the experiments by the Commissioners of Irish lighthouses. They were intended for and are now fixed up at the lighthouse on Mew Island, coast of Ireland. It should be observed that the four gaslights themselves, being much closer to each other than the three electric lights, the lenses were brought much nearer to each other, and instead of the wide spaces of four feet as between the electric lenses, the fixed gaslight lenses were not separated by more than half a foot, and the revolving lenses were practically joined together, forming a continuous mass of glass nearly seventeen feet high.

In lantern C three segments of a lenticular belt, similar in all respects to those in the gas lantern, were mounted for the fixed light, but owing to the great distance apart of the oil burners, the lenses were separated by distances of three feet, which naturally told against the pillar of oil light in comparison with that of four compactly fitted gas burners, shining through four lenses practically not separated. In the revolving light an endeavour was made to compensate for this defect by the use of lenses of larger vertical section, such as are employed at the Eddystone. With these larger lenses, made by Chance Bros., of Birmingham, the outer rings were of flint glass, which has a higher refractory index. The horizontal dimension, and the focal distance of these lenses were the same as those in the gas tower. The height only was different, it being apparently sought to make up by lens-power, or lens-area, for the want of a fourth light.

This completes the three divisions I ventured to make at the commencement of my paper, and it will be evident to all that very careful and elaborate arrangements with the aid of burners and lenses have been made in each case to get the most out of each illuminant, and to exemplify each lighting system effectively at South Foreland. But the value of a lighthouse illuminant is not reckoned solely by the brightness with which it shines through the darkness of night. For clear weather the lights of ordinary power were and are sufficient for the use of the mariner, provided a sufficient individuality be given to each by which it can be readily recognised. The whole purpose of developing these larger and more powerful lights is to overcome the resistance offered to the passage of light rays through the atmosphere, by the obstructing medium of watery vapour in its various gradations from thin haze to thick fog. The times have long gone by when merchant ships would anchor if even a small fog appeared; now-a-days maritime traffic round our coasts stops for nothing. Sound fog signals have become a necessity of the times, to be sounded so soon as the effectiveness of lights is seriously impaired by a thickened atmosphere. But it is very desirable that the lights should hold out as long as possible; that though the effect of a haze might be to lessen the range of a light, yet that its rays should penetrate sufficiently through the haze to be of some practical service to the mariner, to be seen by him in time to prevent his running into danger, or to guide him on his way. If any one illuminant is proved to be able to cope more successfully than the others with this obstructing medium, that light can certainly claim to be superior for lighthouse purposes in thick weather. This, then, is the great problem which is to be solved: which of the three systems, oil, gas, or electricity, when exhibited under the most favourable conditions, has the greatest penetrative power in thick weather? And in connection with the solution of this problem it will be found that considerations of economy and convenience cannot be dissociated from the question.

It will, doubtless, be evident that the question of the relative merits of lighthouse illuminants is considerably more complicated than the general public think it is. We have seen what is the nature of the competitive illuminants, and how they are dependent on burners and lenses to make them serviceable for lighthouse purposes; also how they were exemplified in A B and C towers at South Foreland. We are, therefore, better prepared to enter upon the direct consideration of the actual trials.

A few words may here be interpolated regarding the personal arrangements for carry-out the experiments.

Upon the dissolution of the Illuminants Committee, for reasons which need not be discussed here, this tangled question was by the Board of Trade referred to the Corporation of Trinity-house, who accepted the responsibility of carrying out the investigation, seeing that a great deal of public interest had been drawn to the question. A Committee was formed of members of the Corporation, consisting of Captain Sydney Webb, the deputy-master, as chairman; Captain Nisbet, Captain Weller, Captain E. A. Vyvyan, Captain Burne, Admiral Sir Leopold McClintock, and Mr. John Inglis, secretary to the corporation; to this committee I had the honour of being appointed secretary The first thing done was to obtain the friendly co-operation of the Scotch and Irish Lighthouse Boards, and it is only proper to state that such co-operation was most cordially extended by both Boards and their officers to the Trinity-house Committee. The Committee had the great advantage of frequent personal communication with Mr. Thomas Stevenson, the eminent engineer to the Scotch Lighthouse Commissioners, and with Sir Robert Ball, the Astronomer-Royal of Ireland, and Scientific Adviser to the Commissioners of Irish Lights. They also invited, and were fortunate enough to secure, the aid of Professor W. Grylls Adams, F.R.S., of King's College, London, and Mr. Harold Dixon, of Balliol College, Oxford, the former for advice and assistance in respect of the electric lighting apparatus, the latter for aid in carrying out the necessary photometric observations on the various lights to be exhibited. In addition they had the great advantage of frequent consultations with Mr. Vernon Harcourt, F.R.S., of Trinity College, Oxford, who watched the trials on behalf of the Board of Trade, and whose knowledge of photometric work is probably unequalled in this country; further, the invaluable practical experience and profound knowledge of lighthouse experiments of Sir James Douglass were at all times available, and the suggestions and opinions of representatives of foreign lighthouse authorities were cordially given and received.

It was in full view of all the world, and specially all who were in any way interested in the subject, that the experiments were commenced and carried through; the whole arrangements were open to the fullest and freest public inspection. It is essential to make it quite clear that the Trinity House Committee courted inquiry, suggestion, and inspection. They only desired to arrive at a just decision; and I, as secretary to that Committee, and with all respect to those who may have been inclined to think otherwise, venture to challenge anyone to prove the contrary.

The South Foreland station was selected for the trials because of the existing facilities for observations on land and at sea, and because there was a sufficient reserve of steam power, over and above that required for the machines feeding the permanent lights, to operate the additional electric machines. The land in the neighbourhood of South Foreland is undulating, but has no hedges and few trees, and therefore affords facilities for observing the lights at distances of between two and three miles.

It may be assumed that the three lighting systems were adequately represented by the apparatus set up at South Foreland; the arrangements for exemplifying the electric and oil systems in A and C towers, were made under the immediate direction of the Trinity-house Committee and their engineer, Sir James Douglass. The exemplification of the gas system was left in the hands of Mr. Wigham to arrange, as he thought best, for the exhibition of his quadriform light. It is true that the Committee demurred to making trial of what Mr. Wigham called his double quadriform, *i.e.* two sets of four lights placed side by side in the lantern, which he urged upon them, they not having any practical experience of the effect of burning eight large gas flames in a lighthouse lantern for several hours, nor could they learn that the Commissioners of Irish lights had had any such experience. With this limitation only, Mr. Wigham had perfect liberty to show the best light he could produce with four large burners placed vertically; his foreman, Mr. Higginbotham, might use as much or as little gas as he thought proper; he might regulate his draught as he liked; he had the gas manufacture under his own supervision, and made as much, or as little as, and of what quality, he pleased; the cannel coal was specially selected by Mr. Wigham, and no restriction of any kind was placed upon his foreman as to the mode of keeping up his light. He was simply required by the committee to show a certain light at a certain time, in order that it might be compared with another light, and it was entirely his own business how he produced that light. He was not controlled in any way whatever, and I can testify that it was through no default on the part of Mr. Higginbotham that the gas light did not out-shine the most powerful electric beam. Mr. Higginbotham's mechanical ingenuity always being applied to improve the gas-light, and his devoted loyalty to the interests of his employers, were noticeable points in connection with the gas-light exhibition. A Trinity-house lightkeeper was on duty in this lantern, but he had no power to interfere with Mr. Higginbotham's management of the light. It should also be mentioned that the electric and oil towers were manned by Trinity-house keepers, over whom, as well as over the whole experimental establishment, Mr. J. Sparling, the very intelligent engineer in charge of the South Foreland permanent station, exercised a general supervision, subject to the members of the Committee, who it was arranged should be constantly on the spot.

OBSERVATIONS.

Assuming all the necessary arrangements to have been made for exhibiting the various lights at the South Foreland, the next matter for consideration is how they were observed. It was resolved that two kinds of evidence should be obtained in reference to the relative merits of the illuminants as shown, the one of a practical nature from competent eye witnesses at various distances, the other of a more scientific or expert character. With regard to the former, it may be stated that from the lightsmen on board the *Gull*, the *Goodwin*, and the *Varne*, lightships; the pilots and masters of vessels navigating in the vicinity; the Elder Brethren of Trinity-house and their officers; the Coastguardsmen between the South and North Forelands; valuable data were obtained respecting the relative merits of the lights in different kinds of weather, and at various distances from one to twenty-four miles. In addition to the observations so made at sea and on land, special watchmen were detailed to observe the lights nightly at shorter distances, along a line marked off by posts 100 feet apart, and running across the country for a total distance of two and a half miles, all the competing lights being fully visible in clear weather along the whole length of this line. Three huts were set up along this line—No. 1 at a distance of 2,144 feet, or nearly half a mile from the lights; No. 2, 6,200 feet, or nearly one and a quarter mile; and No. 3 at the extreme point, two and a half miles. The night walks along the lines, the blinding effect of the lights, and the welcome shelter in the huts will, doubtless, be remembered with interest by many of the visitors who joined the observing parties. This short range was very serviceable on nights when haze or fog prevailed, it being possible to measure with a very fair approximation to accuracy the distance at which each light was observed. The observations made were recorded in books specially prepared for the purpose, on a uniform system; thus all the returns were made in the same way. The instructions were as follows:—

INSTRUCTIONS TO OBSERVERS.

The lights to be observed will be shown from three towers in a line bearing N.W. from the permanent high lighthouse, and will be identified by means of the letters A, B, and C respectively.

When possible, observations of the three lights should be made at each hour from 8 p.m. to midnight.

In recording an observation, put down in the A column the light from the A tower as 100, and in the corresponding B or C column put down the number as compared with 100 which represents the difference in power. Thus, if B appears to be twice as good as A, and C appears to be only half as good as A, the record should be A 100, B 200, C 50. In the column headed "Place of Observation," it is requested that the position and distance from South Foreland may be stated as accurately as possible at every observation recorded.

The state of the atmosphere each night is to be carefully noted, and recorded in the column provided for the purpose, in one or more of the following terms:—Clear; cloudy; very dark; moonlight; hazy; slight fog; ordinary fog; thick fog; drizzling rain; ordinary rain; heavy rain; snow; hail; sleet. Each night's record to be signed by the observer, the place of observation being in every case clearly indicated.

Remarks of a special nature concerning the appearance of the lights are to be made on the fly-leaf provided for the purpose. Under this heading observers should record any apparent difference in the colour; any apparent unsteadiness, variations, or obscurations of the lights; also the effect of the lights upon the clouds; and, where a fair comparison is possible, of the relative value of other lights in the vicinity, those on the French coast, for example.

The other kind of evidence sought to be obtained was that of the scientific measurement of lights by the most approved photometrical methods. These operations were carried on at the three huts before mentioned, and in a dark gallery 380 feet long, specially constructed for the measurement of large and powerful lights. This portion of the investigation was mainly in the hands of Mr. Harold Dixon, who had the advantage of frequent communication with Mr. Vernon Harcourt on the subject, and able assistance in carrying out his work from Sir James Douglass, Messrs. Lyle and Longford (who at Dr. Ball's suggestion were sent to South Foreland as the representatives of the Irish Lighthouse Board), and Mr. Sparling. All the various lights exhibited were subjected to measurement both as naked flames and as shown through lenses, the value of each being expressed in numbers of candles. For these measurements the Harcourt pentane standard flame, adjusted to correspond with accuracy to the average flame of a number of sperm candles, was chiefly employed; but occasionally a portion of the flame of a mineral oil Douglass burner, enclosed in a square iron-sided lantern, was used. A small opening in one side of this lantern was fitted with a Methven screen, so adjustable that the rays passing through the opening would represent $\frac{1}{4}$, $\frac{1}{2}$, 1, 2, 4, or other convenient candle-power, as might be desired, in accordance with the single flame of the pentane standard. A portable pentane lamp was generally used in the huts, but on windy nights the Douglass flame was found to be very serviceable, being less sensitive than the unprotected pentane flame. In the photometric gallery, a standard pentane flame in connection with a complete apparatus for making the gas on a sufficiently large scale was available. Without going into detail respecting the manufacture of the gas and the special merits of the pentane standard of light, I may here record the fact that with its aid a great deal of valuable and trustworthy work was done.

Although I do not propose to enter upon a detailed consideration of the photometric methods employed by Mr. Harold Dixon and Mr. Vernon Harcourt, the subject being one which could not be adequately discussed in the space of time at my disposal, yet some remarks of a general character may be made upon the subject.

Let me first say, for the benefit of those to whom photometry is a dark study, that the standard light is that in comparison with which the light under test is to be measured. The value of this standard light is expressed in candle-power.

At South Foreland, the naked lights were measured in the photometric gallery, and the lights through lenses at No. 1 or No. 2 hut. The principle mostly adopted with the former was to cause the light of the standard flame to fall on one side, and that of the light under measurement upon the other side of a movable screen with a translucent star disc in the centre. By moving the screen to and fro along the graduated bar, a position could be found where the stars would show with equal distinctness on both sides of the screen. In such circumstances, the illuminating power of the burner under measurement would be directly as the squares of the distances between the disc and the burner, and between the disc and the standard light.

A modification of this method was occasionally employed in the gallery, and always at No. 1 hut, distant 2,150 feet from the lights. The light of the standard flame, and that of the illuminant under test, were thrown upon the same side of a disc of translucent paper fixed in the centre of an opaque screen, while, by means of an umbrant or shadow-thrower, contiguous portions of the disc were illuminated by the standard and the distant light. By moving the table nearer to or further from the standard, a position was found where the illumination in the three divisions of the disc appeared to be equal. By this method direct measurements of all the lights in A, B, and C towers could be made at No. 1 hut.

At hut 2 the bar photometer with the movable star disc was used, but owing to the great distance from A, B, and C lights, 6,200 ft., it was found necessary to condense the light from the distant towers by a small achromatic lens interposed in the path of the beam entering through a circular opening in the window screen. In thus condensing the light, a certain loss by absorption and reflection was experienced, but in all measurements the requisite correction on this account was applied.

In this connection it was feared that the difference of colour between the light of the electric arc and that of the standard flame would be a serious difficulty, and would prevent an effectual comparison being made as to relative illuminating power of the different coloured lights. But Mr. Dixon says "that with the use of the star disc no such difficulty was felt. Equality of distinctness in the pattern of the star on both sides of the disc could be judged without difficulty, although both star and back ground appeared of complementary tints on the two sides. Since the object of the investigation was to determine for each illuminant the total quantity of light which affected the eye and conferred visibility upon the lamp, independently of its colour, the distinctness of a pattern, illuminated by lights of different colour, seemed to afford a criterion of their true illuminating power less open to error than any method of striking an average between the illuminating power of separate groups of coloured rays filtered from each beam by the interposition of coloured media. It was also found that different observers made concordant measurements of the electric light with the star disc."

The lights were exhibited, watched by many observers, and measured by the indefatigable photometrists over a period of twelve months. During that period a large amount of valuable evidence was collected, by the aid of which the committee were subsequently enabled to state their conclusions with definiteness.

RESULTS.

At a comparatively early stage of the trials it was found that no practical advantage was gained by superposing electric lights, but that, for the reasons previously stated, a sufficiently effective result was obtained from one arc fed by two electric machines. This form of light was accepted by the Committee as that best suited for the exposition of the electric system, and that upon which it should be judged in respect of its merits as a lighthouse illuminant.

For gas, the columnar light of the quadriform arrangement, with a burner of 108 jets for each tier, was the highest power available, and was regarded as the best representative of the gas system.

For oil, the Committee had resolved to rely upon the performance of the six-wick burners, which had been in use in the Trinity House service for many years; and three of these, mounted in triform arrangement, as has been described, were adopted by the Committee as representing the best effect which could then be produced with the oil system.

It will be plain that for the large flame lights there was ample recognition of the value of the system of superposing, a recognition, doubtless, very gratifying to Mr. Wigham, who successfully developed the system with his gas apparatus, although others may have tentatively preceded him in the same direction. It was certainly proved by the trials that the system possesses some real advantages. But it is very essential that provisions be made to check the radiation of heat from the flue pipes. With the superposed oil burners effectual measures were adopted, but not in the case of gas, consequently with the four great gas lights burning in a lighthouse lantern, the heat generated would be so considerable as to endanger the safety of the lenses, and render the lantern uninhabitable. Mr. Higginbotham, Mr. Wigham's foreman, bore the heat in the gas lantern at South Foreland like a genuine salamander; but there are some lighthouse keepers, who would be likely to frizzle and grill under such conditions. I may mention that the temperatures in the lantern, when the four burners were alight, ranged from 180° F. in the lowest tier, to 370 F. in the highest. It was this great heat, taken in conjunction with the cracking of some of the lenses, which influenced the Committee in declining to try Mr. Wigham's double quadriform light, in which eight instead of four burners were to be burned in the lantern. If four burners made the temperature 370°, what would eight burners have done?

A great number of experiments were of course made with the lower powers of the respective illuminants, and information gained which will be of very great value in the lighthouse service; but in stating the results of the trials, it will be sufficient to regard each light as shown at its highest power, viz:—Electric, one light, two machines; gas, four lights, 108 jets; oil, three lights, six wicks.

Clear Weather.—In fine weather it was evident that all the lights were too good, and that for merely sending an effective beam of light to the horizon on a dark clear night, no one was really better than another, although it may be said that the experimental electric light was regarded as a nuisance rather than otherwise by mariners in the near neighbourhood of the South Foreland. It is quite certain that for clear weather the lower powers of any one of the illuminants would be sufficiently serviceable for the requirements of the mariner, either as a fixed or a revolving light. This is proved by the reports made by distant observers, who, on a clear night, would record that the single lights were not less effective than the triform or quadriform arrangement. In this connection, *i.e.*, as regards clear weather, the only points really noticeable are in respect of the adaptability of the lights for occultations, one of the distinctive characteristics used for lighthouse lights, and for marking special dangers by means of coloured sectors. As regards occultations, it is clear that, although with the electric light a simple arrangement might be devised of breaking contact and renewing it at certain periodic intervals, it would not be accomplished without some risk to the steadiness of the light, and, moreover, would not be worth while, because the generation of electricity would still be going on, and nothing would be saved. In the case of oil, it is not very easy to turn the light up and down to produce the effect of occultation. If it were, some saving in oil consumption might perhaps be gained, but it would be very small. To produce occultation with electric and oil lights it is therefore necessary to employ a simple mechanism, by which a cylindrical screen falls and eclipses the light for the requisite period, and is then drawn up. But with gas, the turning off and on of the supply is sufficient to produce occultation in an economical and effective manner. This is certainly a point to the credit of the gas system, but its effective application is limited to fixed lights, for it is questionable whether this kind of occultation can be applied with success to flashing or revolving lights.

For coloured sectors it is necessary that the limiting radii should be as sharply defined as possible, that mariners may know immediately they go over the border line. With large flame lights, the border lines are not clearly defined, but instead are found areas of uncertain light of varying width. With the electric light this width is only a few feet at a distance of 1¼ mile; with the gas light at full power it is over 140 feet at the same distance; and with the oil light at full power it appears to be between 50 and 60 feet. The changing of the points of incandescence in the carbons causes the electric light line to move within a range of 15 feet, but the line of definition is always sharp. The width of the uncertain light increases in proportion to the distance, and it is consequently of importance to obtain the sharpest possible definition of the sector. Electric, for this, is certainly the best, the oil system, with 6-wick burners, being a good deal better than the gas system with great 108 jet burners.

Haze and Fog.—We now come to the question of haze and fog.

The gradations of atmospheric transparency are numerous, and it is between such extremes that the mariner finds powerful lights specially useful. It is when the atmospheric transparency is impaired more or less that these strong lights are required. It is very difficult to graduate the opacity of the atmosphere, but for our purpose it will be convenient to separate weather which in a general way is misty or hazy from that which is essentially foggy.

The general result of all the observations made in respect of haze, show incontestably that the single electric light, as shown from the A tower, greatly excels the most powerful superposed gas or oil light in penetrating power, either as a fixed or revolving light. Of 284 eye observations recorded as made in weather not clear, but without actual fog, the mean per-centage of superiority of the electric light over gas is about 36, and over oil 41. These per-centages must not be taken literally, they are are not intended to convey exact numerical ratios, but are founded upon the estimates of many and various observers at different positions, and possibly under different conditions. But the general verdict of superiority of the electric light in such conditions of weather is plain and unmistakable. It is always better than anything else.

As regards gas and oil, 231 observations of quadriform gas, 108 jets revolving, as compared with triform oil 6 wicks revolving, made at times when the transparency of the atmosphere was impaired by mist, haze, rain, or snow, show that the gas light has a mean per-centage of superiority of 5·8 per cent. When shown as fixed lights, the superiority of gas over oil is increased to 12·2 per cent. as the mean of 72 observations. In this case the body of miscellaneous observers give their verdict that the gas light is better than the oil light. This advantage does not mean that the revolving gas light penetrates to a greater distance than the revolving oil light, but merely that at the points of observation, near or far where both are seen, the gas light is regarded as better than the oil light. But, for all practical purposes, the oil light is seen whenever the gas light is seen, although it is evident that the gas is the better light of the two, as it ought to be with its four lights against three. As a fixed light, the gas certainly has the best of the oil. The four closely packed 108-jet gas flames showing through their closely-fitted lenses, yield a column of light very superior to that of the three widely separated 6-wick oil lights. As exemplified at South Foreland, the oil light was beaten by the fixed gas light. But without stopping to inquire whether a better effect could have been made with the fixed oil light, it may be said that fixed lights are gradually becoming of less importance, owing to the necessity for providing lights with distinctive characteristics, for condensing the rays into strong beams, and to avoid lighthouse lights being mistaken for anchor or other lights on board vessels at sea.

In actual fog the electric again holds its own. The experience of fogs at South Foreland, though not large, was sufficient to furnish valuable comparisons, and it was proved beyond question that the single electric light pierced a greater depth of fog than the highest powers of either gas or oil. The quadriform gas and triform oil lights were practically equal in fog, though some observers occasionally recorded the gas as a few feet better. But in such fogs the mariner would not derive the slightest advantage from any light. The recorded distance to which lights were carried, or where they were picked up in the fog, range mostly between 700 and 2,000 feet from the lights themselves, and the superiority of the electric light is determined by its penetrating 200 or 300 feet further than the gas or oil lights. The most powerful electric light was shut out on one occasion at 1,450 feet, on another at 1,500, another at 1,700, on another at 1,500, another at 1,300 feet. It will be plain to all here that no mariner could possibly be benefited by a light which was not visible at such distances from the lighthouse. And for purposes of navigation a difference in the visibility of the lights of 200 or 300 feet is of no value whatever. One remarkable fact stands out prominently here, viz., the greater ratio of absorption by the fog of the electric rays as compared with the gas and oil rays. Fortunately for the electric light, as shown at South Foreland, it possessed a large reserve of initial intensity, which enabled it, notwithstanding its much greater proportion of loss by absorption of its more refrangible rays, to penetrate further than the other illuminants. With three lights of equal candle power, one electric, one gas, one oil, exhibited in a foggy atmosphere, there is little doubt that the electric would be eclipsed at a much shorter distance than the others; but as the electric beam can be made so much more intense than it is possible to make the gas or oil beam, the electric light, though heavily handicapped, beats its competitors in fog by the superabundance of its own luminous energy.

Such, then, are the results obtained from the testimony of eye witnesses. The photometric measurements entirely corroborate the eye observations as to the superiority of the electric light in all weathers, both in revolving and fixed phase. They also give the 108-jet gas burner a superiority over the 6-wick oil burner, when both were shown through similar lenses; and, taking the mean of all weathers, the former is credited with an advantage of 16 per cent over the latter. But it is important to note Mr. Harold Dixon's remarks on this point. He says "this difference in illuminating power means but slight difference in penetrating power. In many observations, both on sea and land, in haze and in thick fog, the quadriform 108-jet gas light was picked up just before, but only just before, the triform 6-wick oil light; in other observations the two lights were picked up simultaneously." This exactly coincides with the evidence of the eye-witnesses, and supports the belief that the four lights in the gas lantern just managed to hold their own and no more against the three lights in the oil lantern.

The Table in p. 433 gives the value of all the burners in clear weather. The results are stated for a single burner in each case, but to obtain the value of quadriform gas or triform oil, it is only necessary to multiply by four or three.

The experiments have shown clearly that, light for light *i.e.* diameter for diameter, gas and oil are very much alike in illuminating power; indeed, under such conditions, the oil flame seems to be rather the better. They have also shown that oil lights can be superposed with the same facility as gas lights, and can be exhibited under similar conditions, with one exception, that no oil flame has yet been brought to the enormous size of the 108 jet burner. But as this enormous size of flame is not required, this is not of great consequence. As the two lights were shown to be so nearly equal, the questions of convenience and economy assumed very considerable importance in connection with their relative merits as lighthouse illuminants. It had to be considered that the gas system could not be taken to a rock lighthouse or used on board a light vessel, therefore its application would have to be limited to lighthouses on the mainland. The necessity for the erection of gasworks, gasholders, mains and pipes, &c., involved a large expense, all of which might be justifiable if the advantage to be gained were proportionate. But, on the other hand, mineral oil was found to be so cheap, so easily supplied and stored, and so easily managed, that the balance of advantage was seen to be distinctly in its favour. Here is the real enemy which has beaten the gas system. As I before observed, the arguments employed in the early part of this discussion to demonstrate the economy of the gas system were based on the then prices of rape seed oil at 4s. 9½d., 3s. 10½d., 2s. 9d. per gallon, but times are changed; mineral oil has now replaced the high priced rape seed oil, and is supplied at 6d per gallon.

TABLE OF PHOTOMETRIC VALUES.

Name of Burner.	Dimensions of the flame.			Illuminating power in candles (mean results).			
					Through lenses in clear weather.		
	On the burner.	At focal plane.	Height.	Naked flames.	Cylndr.belt.	Eddystone.	Mew Island.
	inches.	inches.	inches.		fixed light.	revolv. light.	revolv. light.
6-wick oil, Douglass, old pattern	4¾	4⅜	5	730	5,000	64,000	48,000
7-wick oil, Douglass, new pattern	5⅞	4⅜	6	947	8,100	60,000	49,000
8-wick oil, Douglass, new pattern	7½	5⅝	6½	1,400	...	...	...
9-wick oil, Douglass, new pattern	7½	5⅝	6½	1,785	...	...	...
6-ring gas, Douglass (cannel).........	4⅜	2⅞	5	825	6,700	92,000	70,000
10 ring gas, Douglass ,, ...	7½	5⅝	6½	2,500	12,899	105,000	94,000
108-jet gas, Wigham ,, ...	11¼	11¼	13*	2,300	15,600	...	59,000
88-jet gas, Wigham ,, ...	9½	9½	13*	1,400	13,000	...	54,000
68-jet gas, Wigham ,, ...	7¾	7¾	13*	990	8,800	...	48,000
48-jet gas, Wigham ,, ...	6	6	12*	680	5,700	...	42,000
28-jet gas, Wigham ,, ...	4¼	4¼	12*	250	3,000	...	33,000
Regenerative gas, Siemens (cannel)	10	10	6	600	3,300	10,000	...
Regenerative gas, Siemens, small size (cannel)......	4	4	4	194	...	...	...
6 ring gas, Sugg (cannel)........	7½	7½	8½	824	5,600	55,000	...
						Cylndr. belt with vertical prisms. revolv. light	
Electric, 1 machine	...	...	...	10,000	120,000	1,250,000	...
Electric, 2 machine	...	...	...	15,000	150,000	1,500,000	...

* 4½ to 5 inches of these heights are naked flames, the remainder is surrounded by a transparent talc chimney.

It is this fact which has demolished all elaborate computations to prove the economy of gas. Notwithstanding Mr. Wigham's great ingenuity and perseverance, circumstances over which he has no control have vanquished him; and if at any time Mr. Wigham can bring down the price of coal-gas so that the light is less costly than that of mineral oil, he may reasonably expect that oil will then have to take a back seat. But that time is not yet.

The whole result may be approximately stated as follows:—For expenditure of raw material only, without reference to plant, labour, &c., a six-wick mineral oil lamp burning for six hours would consume four gallons of oil at 6d.=2s., or, say, 3s. including wicks, cylinders, &c. A 108-jet burner alight for the same period would consume 1,800 cubic feet of gas, at a cost of not less than 10s. for coal alone. Taking all these considerations into account, it will not be surprising to this audience to hear that the final conclusion of the Committee was:—

"That for ordinary necessities of lighthouse illumination, mineral oil is the most suitable and economical illuminant, and that for salient headlands, important landfalls, and places where a very powerful light is required, electricity offers the greatest advantages."

DISCUSSION.

The CHAIRMAN, in opening the discussion, pointed out the thorough manner in which the testing of the lights in the experiments spoken of had been carried out over long intervals of time, and under a variety of circumstances. No doubt, therefore, could attach to the conclusions arrived at. From a practical point of view, one of the most interesting results was the short distance penetrated by the most powerful lights, and it seemed that a doubling or trebling of the lights in many cases very little increased their power of penetration through fog. Perhaps, after all, that was what might have been expected, for when powerful lights of many thousand candles were entirely quenched at the distance of a few thousand feet, it was evident that in every few hundred feet of that distance the lights must be diminished in considerable proportion. Further particulars as to the less penetrating power of the electric light as compared with oil or gas would be interesting. To a certain extent people were misled by ordinary London experience of fogs. It was a matter of common observation in London, a few years ago, when the electric lights were burning on the embankment, that at a very moderate distance they seemed to be almost as red as the gas lights burning beside them, but that effect was more likely to be produced by the London smoke rather than by what could be properly called fog. When the sun at midday is shining through a bank of cloud which allows its outline to be visible, it is seen not altered in colour, but in its original whiteness. At sunset, it was true, when the sun shines through a lower stratum of the atmosphere, a red colour is perceptible, but that appearance could not properly be attributed to fog or cloud, otherwise the same effect would be observed when the sun was high in the heavens, and its rays had to pass through a mile, or a mile and a-half of cloud. A little more than a year ago he had himself witnessed the experiments with these lights, and had spent a very interesting night walking between the huts spoken of, placed at various distances from them, and in observing the effects of the lights, and the careful arrangements made with reference to photometry. As to the comparison of the effect of lights of different colours, he saw the star-disc arrangement spoken of in the paper, and had verified the possibility of taking very accurate observations in spite of difference in colour between the electric and gas and oil lights. Within the last week Captain Abney and General Festing had brought before the Royal Society a very interesting account of some elaborate observations which had been made upon this very subject of the photometry of different coloured lights, and they had proved (rather to the surprise of many) that it was possible to make comparisons between lights of very various colours, between white light and the green, or red lights and the spectrum, almost as accurately (Captain Abney said, within 1 or 2 per cent.) as could be done between lights of absolutely the same colour. In estimating the rapidity of the alternation of the currents, Mr. Edwards appeared to have multiplied the number of coils by the number of revolutions, assuming that each coil sent a distinct pulse. He thought the arrangement was such that each passage of the coils in front of the magnet gave one pulse, so that the number of coils should not be multiplied by the number of revolutions to obtain the number of pulses. He scarcely thought that the number of pulses could be so many as over a million in a minute, as had been stated, but some of the gentlemen present would probably be able to speak upon that point.

Professor W. G. Adams, F.R.S., said that, from his own personal observations and measurements, he could bear Mr. Edwards out in many of the remarks which he made with regard to the relative illuminating powers of gas and oil, and of the electric light, under the arrangements for their comparison which were made at the South Foreland. As regards the comparison of oil and gas, he thought Mr. Edwards had given a full and fair account of their relative merits, and had drawn just conclusions on them. He would strongly emphasize the praise of the Douglass 6 and 10-ring gas-burners, for he felt sure that all who had had the opportunity of judging must be of opinion that for the compactness of the burner, the concentration and steadiness of the flame, and for the remarkable economy of gas, these Douglass gas-burners far surpassed any other gas-burner which had ever been tried for lighthouse work. The 6-ring burner, $4\frac{1}{2}$ inches in diameter, gives the light of 108-jet gas, $11\frac{1}{4}$ inches in diameter, and only consumes one-third of the amount of gas consumed by the 108-jet burner. The 10-ring Douglass gas-burner, $7\frac{1}{2}$ inches in diameter, gives 60 per cent. better light, and only consumes two-thirds of the gas of the Wigham 108-jet burner. The relative smallness of these flames is of great importance in their use behind a lighthouse lens. And here he would draw attention to a fallacy which seemed to exist in certain quarters, and from which Mr. Edwards did not seem to be quite free, but which had been fully proved to be a fallacy by the experiments at the South Foreland. It is assumed that a second order lens, or even a third or a fourth order lens, is quite large enough for a source of light of small size like the electric light. The results, as given by Mr. Edwards, have shown that if the object was to prove the superiority of the electric light over any other light for lighthouse use, then the second order lens was quite sufficient to show this superiority under any conditions of weather. As long as oil and gas flames were of moderate size, say four inches in diameter, second order lenses did fairly well; but when flames 6 or 8 inches in diameter came into use, there was found to be little or no increase in the light, and so the lenses too must grow, and we must have Fresnel's first-order lenses. Then, again, the flame grows to 10 or 11 inches, and even first-order lenses give very little increase over smaller flames, as shown by comparison of Wigham 88-jet and 108-jet gas in Mr. Edwards' table; and so it becomes necessary to construct a lens, as Mr. Stevenson has done, which considerably exceeds in size what has hitherto been called "the first-order lens." The experiments at the South Foreland have shown, and Mr. Edwards' table proves it, that lights concentrated into a smaller focus, and especially electric lights, gain more than any others by the use of larger lenses. Compare the Douglass 6-wick oil (730 candles), the Wigham 68-jet gas (990), and the Douglass 6-ring gas (825), when used behind the same Mew Island lens. Much more is this the case with the electric light. Had Mr. Edwards completed his table, and given the illuminating power of the electric light through the Mew Island lens, as given in his (Professor Adams's) report, the numbers 15,000,000 and 18,000,000 would have been seen in the last columns of that table as compared with 59,000 for the 108-jet gas. The multiplying power of the lens for the electric light would have been 1,500, whereas for the 108-jet gas it is only 25, and about 38 for the Douglass 10-ring gas. It will be seen that, with the cylindrical belt with vertical prisms, the multiplying power for electric light is 125, and for the Mew Island lens it is twelve times as great, or 1,500. For the adequate comparisons of the electric light with other systems of lighthouse lighting, it is essential that the same lenses should be used, and for this as well as for some other reasons, we must look upon the results of the South Foreland experiments as only showing that the electric light is superior to every other light, but not by any means as showing what the electric light is capable of doing. His (Professor Adams's) report showed that much more has been done, and that under favourable conditions far more of the electric energy can be converted into light-giving rays. The merits of the electric light as a lighthouse illuminant cannot, as his report showed, be arrived at simply by the results as shown from the A tower at the South Foreland, without taking into account the loss of energy to which Mr. Edwards had alluded, and which would not exist in any permanent installation. With regard to these experiments, he (Professor Adams) had been asked by practical men how it is that so little light as 10,000 or 12,000 candles is obtained from the expenditure of so much energy, when we get more efficiency and far more effective work from our dynamo machines. To some extent this is true, and may easily be accounted for. A machine does most effective work when the external resistance of the circuit is not greater than the internal resistance of the machine; now in this case the internal resistance of the De Meritens machine is ·05 ohms, and the resistance of the leading wires to the tower (to say nothing of the lamp and the electric arc) is ·077 ohms, or more than half as much again. Hence it will be evident to all practical men that these excellent De Meritens machines can do far more than has hitherto been done with them. Whereas the light in the A tower is given by a current of 100 ampères, or at most 130 ampères, the machine has given a current of 420 ampères when the electric lamp was not far away from the De Meritens machine. With regard to the apology of Mr. Edwards, or the reason he alleges why the electric light has not been used in England, although it has been received more favourably in France (on the French coast there are 42 electric lights), he would ask if the mariners ever object to the dazzling brightness of the sun, and if the electric light does not more nearly resemble brilliant moonlight? Mr. Edwards said the electric light was removed from Dungeness, because mariners disliked it, but he (Professor Adams) had shown in his lecture at Aberdeen, before the British Association, what mariners thought of the electric light of the South Foreland when it was first established there; he quoted from a work of M. Petit, translated by Mr. Edwards. M. Petit says:—"The advantages of the system have been highly appreciated by mariners, and the increase of range of the lights has been very marked in slightly foggy weather. It certainly enables mariners to continue their voyage, and to enter a port at night, when they would not have been able to do so with oil lights." M. Petit for many years was Commander of a steamer on the postal service from Ostend to Dover. To M. Petit's paper, and to his (Professor Adams) report to the Trinity-house, as well as to his lecture at Aberdeen, he must refer for proof that the step from oil lights of 1870 to electric light of 1884 represents an improvement in the proportion of from 30 per cent. to 90 per cent. in lighthouse illumination, and that the number of nights on which the electric light is seen 20 miles away is about 90 in every 100. On a few very thick nights an increase of 100-fold in the source of light, whether it be electricity, gas, or oil, will hardly increase the distance to which the light is seen by 100 yards. He thought Mr. Edwards must have made a mistake in his description of the mode of coupling the machines. The two machines coupled parallel have an E.M.F. of 60 volts, and a current of 176 ampères, and the two machines in series are said to be also of 60 volts, and a current very nearly the same; these values seem to show that in this case the coupling must have been also parallel, probably the opposite poles of the magneto machines were connected. He was glad to hear Mr. Edwards state that the electric light can generally be maintained with a fair amount of steadiness, and that the fluctuations have not been very serious, but I think no friend to electric lighting can ever hold with him that its unsteadiness may be advantageous. As regards the size of lenses used in the A tower, they extended only over 30° of arc, bringing the bundle of rays into a parallel beam, whereas the Mew Island lenses in the B tower extended over 60° of arc, both horizontally and vertically. With regard to the greater absorption of the electric beam by the atmosphere, the experiments with steam fogs had shown that it was by no means so great as was previously supposed. The illumination given by the blue and violet rays is very small, and even if they were absorbed, the total light would not be thereby very much reduced. The experiments at the South Foreland have shown that, using the large Mew Island lens, with the 108-jet gas of 2,400 candles, and the electric light of 12,000 candles with the smaller lens, the electric light in clear weather was at least sixteen times as bright, and in foggy weather was about thirteen times as bright as the gas light, the excess of absorption for the electric light being about 20 per cent. more in foggy than in clear weather. Had the same lenses been used for both electric light and gas, the illumination given by the electric light would have been from 150 to 200 times the light from gas.

Professor C. VERNON HARCOURT, F.R.S., said one of the points of most general importance was that raised by the Chairman as to the relative absorption of the electric and of other lights by the atmosphere in a certain condition. It might be that one of the causes why the electric light was credited with suffering more by atmospheric absorption was that so many observations were made in London, and that London fog differed perceptibly from such haze and mist as was met with at sea; and it might differ in respect of possessing this selective absorption in much greater degree than when the air was simply obscured by suspended particles of water. When there was rain falling, or there was a wet fog, such as was met with sometimes on ascending a mountain, the obstruction to the light was suffered equally by light of all degrees of refrangibility, and it might be that when the water was more finely divided, as in a haze, that this selective absorption occurred where the size of the globules was comparable with the wave-length. He was glad to hear Professor Adams's remarks as to the degree to which absorption reached. Becquerel stated that for solar light the rays from blue to violet were 14 per cent. of the whole; but it had been stated that the proportion of these rays was greater in the electric light than in the solar light; and perhaps in that case the total absorbed in this selective way might be more than 14 per cent. It was very important to have some such limit fixed to the possible loss of light in this way. It was also important to understand that the way in which the atmospheric absorption acted was, as Professor Adams had described' that each stratum of thick air which the light passed through, cut off a certain fraction, and that the same abstraction happened to all light of the same colour, and was of such a character that there might be a great disproportion between the increase which might be produced in the light and the cone of rays which was the consequence of that increase. If the fog were such that one of Mr. Wigham's single lights were extinguished at two miles, the quadriform light would only extend to 2·1 mile, or something like that. Sometimes expressions were used as if it were possible to produce a light of such a kind that it would go clean through a fog, but that was quite impossible. It was not like an engine cutting through a snow drift, which might be too thick for one engine, or even two, to get through, but by putting on three or four they might force their way right through into the clear space beyond. That could not happen at all in any homogeneous haze, but something like it might happen in exceptional cases where the haze was limited in extent, so that the weaker light might, perhaps, just get through; then a more powerful light might go through and travel on, and in that way might appear to have twice the range of the weaker light. It had struck him several times, in witnessing these experiments, that the electric light was tried under less favourable circumstances than any of the others, the only reason he could suppose being that those who were already experienced in it felt perfectly sure that, tried in any way, it would prove the most powerful light. There were smaller lenses, there was the imperfection in the long leads, and one or two other circumstances; for instance, it would have been possible to work one of the arc lights with the whole Fresnel arrangement, as there was no heat given off by the arc, though with gas or oil flames that would not be possible; but the suppression of part of the Fresnel arrangement cut off some 30 per cent. of the available light.

Mr. HAROLD DIXON remarked that the Chairman, who was one of the greatest living authorities on light and colour, seemed to intimate that the red appearance of the sun at sunset was due to the character of the London atmosphere, and that a simple cloud did not produce that change of colour. But they all knew that a sunset at sea had a red tinge, so that he did not think London fog could be the only element in the change; it might be in the different sizes of the globules of water. He should like to ask if comparatively large globules of water suspended in the air would act equally on all kinds of light; and would very finely divided particles of water act selectively, or must there be some solid particles present. He begged to thank Mr. Price Edwards for the great kindness and tact he had shown in conducting the experiments at the South Foreland, where he must have sometimes found it a difficult task to reconcile his duties to the Elder Brethren with the requirements of the scientific gentlemen.

Mr. HENRY WIGHAM said he had listened to the paper with great interest, having been associated with the experiments from the beginning, and also with all his brother's investigations, and he might be allowed to mention one or two points in which his brother took exception to the report of the Trinity-house. As Mr. Edwards had said, he wished to show his double quadriform lamp, but that was objected to on two grouuds; one being that it had not been used in any lighthouse up to that time; but they allowed the electric light to be shown in a more powerful form than it ever had been shown in any lighthouse; and the same remark applied, he believed, to Sir James Douglass's 6-ring gas-burners with cylinders. Another objection to the double quadriform gas lamp was that it might crack the lenses from the heat. The reason why the Irish Lights Commissioners withdrew from the investigation on the former occasion was because his brother was not allowed to use his double quadriform lamp; but it had been tried since the experiments at the Foreland were completed at the Howth Bailey lighthouse, as was witnessed by the Commissioners, by Mr. Howard Grubb, and by Professor Barrett, and the result was to practically double the light. The result of the Trinity-house experiments was that gas and oil were about equal, and that the electric light was more powerful than gas, but if his brother had been allowed to show his more powerful light the result might have been altogether different.

Mr. INGLIS thought the correspondence on the subject proved that the real reason why Mr. Wigham was not permitted to show his double quadriform lamp was the danger which was apprehended from a double furnace, so to speak, in a lantern, which had already been raised by a single one to 370° Fahr. It was also thought that the experiment was not worth trying, because they had already learned from Mr. Harold Dixon's investigations that multiplying lamps meant multiplying power, and, therefore, there was no need to try the experiment and run the risk of breaking the lenses. They might also have said that what could be done by gas could be imitated in oil, and the result would be practically the same, and, therefore, for all practical purposes, the test had been carried far enough. The lighthouse administration in England, Scotland, and Ireland, were quite agreed that gas was a very convenient method of illuminating, but it was more expensive than oil, and they were bound to choose the cheaper illuminant in the interest of those who had to pay for it.

Mr. CROMPTON said that if it were true, as Mr. Wigham had said, that a much better light could have been given with gas had the double quadriform lamp been used, it was undoubtedly true that a much better light could have been given by electricity. The whole electric apparatus was antiquated, and electric engineers could hardly understand why it was shown. The figures given by Professor Adams in his report showed that they generally got from 1½ to 2 candles per watt, whereas in ordinary commercial arc lighting they got 4½. Professor Adams had explained some of the reasons for this enormous difference, but not enough to account for more than a small per-centage of it. He took it from experience in connection with military and naval search lights, that the loss was mainly in the electric light being smothered between the enormous carbons which were used. For military and naval lights they got over that by throwing the light in one direction, and having one carbon larger than the other they were able to get a glowing disc—a light crater—on the positive carbon. Then the question arose, would a light all in one direction do for this purpose? Well, for revolving lights it was the very thing; for an all round fixed light the difficulty of managing it was increased, but it could be overcome. Some makers in America, and others in England, were getting extraordinarily steady current light from a surface of glowing carbon by means of multiform negative poles. It had never been considered worth while to work that out, because the Trinity-house so far had been content with the De Meritens magneto-electric current machine and the Berger lamp, both of which were obsolete. He had gone carefully into the figures of the report, which he thought were hardly fair to the electric light, as they were taken on the supposition that an enormous electric light, twenty times as strong as that of the 108-ring gas jet, should be used at all times. The electric light was as capable of being used for a small light as a big one, and if arranged so as to give sufficient light for ordinary fair weather, the cost of coal, carbons, and attendance would be enormously reduced, and instead of the electric light being shown as rather dearer than gas, and about two and a half times as dear as oil, it might be brought down to about one-and-a-half times the cost of oil. The Liverpool Conservancy Board had been persuaded to adopt it in their lightships, and they were now arranging for it in a new lightship to be built. There, instead of using the dioptric principle, they were going back to the older catoptric system with parabolic reflectors. There would be four lights in each lantern, two burning at a time, and each giving a pencil of light, approximately 30° open, opposite to one another, and revolving twice in a minute.

Mr. PRICE EDWARDS, in reply, after thanking Messrs. Adams, Dixon, and Vernon Harcourt for their remarks, said he thought Mr. Wigham was under a little misapprehension with regard to the Irish Commissioners retiring from the former committee because the double quadriform light was not tried; that was not specifically stated, but there was a resolution passed in general terms with reference to Mr. Wigham showing the best he could. He had been informed that Mr. Wigham exhibited the double quadriform lamp at Howth Bailey at his own expense, that the Irish Commissioners did not see it officially, but as a matter of curiosity from the other side of the water, and there were no particulars of the ventilating arrangements. With regard to Mr. Allard's figures, he believed that since the termination of the experiments he had been describing, the French authorities were holding their hands a little, and were more inclined to continue the use of oil.

The CHAIRMAN, in reply to Mr. Dixon, said he did not intend to draw any great distinction between the atmosphere of London and elsewhere in its effect on the setting sun, except in regard to quantity. Wherever the atmosphere was full of small floating particles, such as pollen (and chloride of sodium they knew was always present) those particles would exercise a light disturbing effect. When the particles were of transparent matter, in size a large multiple of the wave-length of light, they would exercise no selective action; through a cloud of particles of the magnitude of 1-1000 inch, or 40 wave-lengths, the sun's light was of much the same quality as without it. But when the particles were very much smaller, the case was very different. The scattering power of the small particles varied inversely as the fourth power of the wave-length, and, therefore, would be much greater at the blue than the red end of the spectrum, varying continuously all the way down. If the blue light were scattered laterally more than the red, it could only be at the expense of the transmitted light, so that as the light passed through a greater thickness of such a stratum it reddened more and more. But this was not a case of extinction, but of diversion; in some cases it might happen that the light originally diverted came back again to the eye; because the blue light scattered laterally might be scattered laterally again, and thus come out in the original direction; and thus the excessive redness of the light directly transmitted would be compensated by the excessive blueness of some of the light which reached the eye after being scattered. In the paper by Captain Abney and General Festing, this law had been experimentally verified, which was a matter of great interest to him, as it formed the subject of one of the first papers he published nearly twenty years ago. They found that the light transmitted by a turbid medium, a fine precipitate of mastic in water, followed very closely the theoretical law derived from the principle he had just stated. He concluded by moving a vote of thanks to Mr. Price Edwards for his paper.

The vote of thanks was carried unanimously, and the meeting adjourned.

MR. J. N. SHOOLBRED writes:—"It will probably be of interest, taken in connection with Mr. Price Edwards's account of the experiments at the South Foreland, if I give a few particulars as to some of the lighthouses illuminated by electricity on the French coasts, which are given mainly on the authority of M. E. Allard, the Engineer-in-Chief of the Lighthouse &c. service in France—a position corresponding to that of Sir James N. Douglass in this country.

"These statements are rendered more interesting from the fact that the electric machines now in favour with the French lighthouse authorities are De Meritens magneto machines, of almost precisely the same type as used at the South Foreland, while the earlier French magneto machines, known as the 'Alliance,' are almost identical with those used here under the name of 'Holmes,' Professor F. H. Holmes having had (as stated by himself to me) much to do in 1853 with the transformation of the original Nollet machine (made in 1849, being the first electric machine of sufficient size to require the aid of a steam-engine) into the 'Alliance' machine of the French lighthouses.

"Thus the lighthouse authorities on both sides of the Channel have used practically the same electric machines, both in their earlier use of this illuminant, also in their present arrangements, with a more extended knowledge of, and experience in, electric lighting. In all cases it will be noted how they adhered to magneto-electric machines in preference to dynamo-electric ones, despite of the inferior results of the former, as stated by Mr. Crompton. Not that dynamo machines, with the current continuous in one direction, have not been used in lighthouse illumination. The Siemens machines here (and I believe those of Gramme construction in France) were both tried for some time. But they were found to be liable to much more frequent interruptions in the lighting (a matter of the gravest importance in lighthouse illumination) than were the magneto machines, which also gave less trouble in maintenance. Hence the preference for the latter, despite of their alleged inferior efficiency.

THE LIGHTHOUSES LIGHTED BY ELECTRICITY ARE:—

In England.

South Foreland	first lighted Dec. 8, 1858.
Souter Point	first lighted 1871.
Lizard	„ „ 1877.
St. Catherine's, Isle of Wight	(in construction).

In France.

La Heve, Havre (2 lights),	first lighted	Dec. 26, 1863.
Grisnez	„ „	Feb. 15, 1869.
Palmyre, mouth of Gironde	„ „	Nov. 3, 1881.
Planier, „ „ Rhone	„ „	Dec. 1, 1881.
Balcines, Isle de Ré	„ „	Oct. 1, 1882.
Calais	„ „	Oct. 1, 1883.
La Canche (2 lights)	„ „	Oct. 15, 1884.
Dunkerque	„ „	Dec. —, 1885.

N.B.—"Alliance" machines are in use in the first three, "De Meritens" in the remainder.

"It will be of interest to compare the following figures as to the relative cost of lighthouse illumination by electricity and by oil (as given by M. Allard in his "Memoire sur les Phares Electriques," 1880), with those given in the official Report of the South Foreland experiments (Part I., pp. 62 and 63.) M. Allard gives the following as to the cost of the electric installation La Heve (two lighthouses), Havre.

First outlay.

	£
Buildings	13,840
2 Steam-engines	688
4 "Alliance" machines	2,008
8 "Serrin" lamps	480
Optical apparatus, &c.	1,024
Sundries	240
	£18,280

Annual working expenses.

	£
Salaries	277
Repairs, coal, carbons, &c.	400
Maintenance of buildings, &c.	218
Interest at 3½ per cent.	640
	£1,535

For an oil light of the first class M. Allard puts down:—

First outlay.

	£
Apparatus, buildings, &c.	7,200

Annual working expenses.

	£
Maintenance	332
Interest at 3½ per cent.	252
	£584

While in the Report of the South Foreland, the electric light station is placed as:—

First Outlay.

	£
Lantern, optical apparatus, and buildings	14,345
Two steam-engines	1,250
Two De Meritens machines, three lamps, cables, &c.	2,154
	£17,749

Annual Working Expenses.

	£
Wages, coke, carbons, &c.	800
Repairs and renewals	417
Interest at 4 per cent.	710
	£1,927

While for a first-class oil light station, as at Anvil Point, Devon, it gives as :—

First Cost.

	£	s.	d.
Apparatus, buildings, &c.	8,064	18	3

Working Expenses.

	£	s.	d.
Wages, &c.	244	9	11
Repairs and renewals	157	3	6
Interest at 4 per cent.	322	11	2
	£724	4	7

Miscellaneous.

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COLONIAL AND INDIAN EXHIBITION.

Amongst recent arrivals at the Exhibition are Sir Samuel Davenport, Assistant Executive Commissioner, in charge of the South Australian exhibits; Dr. Von Haast (Professor of Geology in Canterbury College, New Zealand), Commissioner in charge of the New Zealand exhibits; Mr. H. E. Wodehouse, Honorary Secretary to the Hong Kong Commission; Mr. Hawtayne, Executive Commissioner for British Guiana; the Honourable James E. Mason, Executive Commissioner for Fiji; and Dr. Watt, of the Bengal Educational Department, in charge of the Economic Section of the Indian Courts. Every colony is now represented at the Exhibition by a Commissioner, who is actively superintending the preparation of his court.

Goods for the Exhibition arrive daily in large quantities, and up to the 11th of March no less than 7,000 packages had passed through the goods entrance, and found their way to their respective courts. As, however, at present, carpenters and decorators hold sway in most of the galleries, the work of unpacking and placing the exhibits has, with the exception of India, not yet proceeded very far, but in a very few days great progress will, doubtless, be made.

Six courts—New South Wales, Victoria, Queensland, New Zealand, the Cape of Good Hope and Natal—will have conservatories adjacent; and the two lower basins on either side of the Central Courts will be spanned by rustic bridges, connecting New Zealand with South Australia, and Queensland with Cyprus.

If the exhibits in the courts are but half as bright in colour as the walls and roofs are now becoming, the Exhibition will be very gay. In many instances the work of decoration has been placed in the hands of Messrs. Gillow and Co.

New South Wales is painted in an arrangement of blue-grey and carmine, with a frieze of birds and flowers; while the neighbouring court of Queensland has walls of French-grey and salmon colour, with red and yellow stripes on the ribs of the roof. In Western Australia, the typical black swan (familiar to every schoolboy who collects stamps), is everywhere apparent on a primrose ground. New Zealand is bright with yellow, vermilion and blue; and the West Indian Gallery is painted in pale blue-grey and buff, with a dull red dado. The predominating colour in the Maltese Court is Indian red, which will harmonise well with the sage green of Cyprus; the latter court will have a frieze of Lotus flower and other designs taken from Cypriote pottery. The Cape Court is being harmoniously treated in sage green, dull red, and drab, while near by the West African section stands out in black and yellow stripes heightened by red. Compared with some of the other courts, the Canadian decoration appears sombre in tone. Along the ribs runs a conventional design of foliage in dull green; and the dado is surmounted by a frieze of a garland connecting medallion heads of Greek deities. In India the decoration of the roof is left to the thousand banners, containing eighteen varieties, which will be suspended from it; but Ceylon is being painted yellow, green and red.

By arrangement with the authorities of the South Kensington Museum, the India Museum will be maintained as an integral part of the Exhibition; and facilities will thereby be afforded for the comparison of the art treasures of that collection with those which will be seen in the Indian courts of the Exhibition. These arrangements will not, however, interfere in the slightest degree with the usual free admission of the public to the museum; but, on the other hand, they will doubtless induce many to visit the museum, who have hitherto passed heedlessly by.

At previous exhibitions, a lack of seats throughout the buildings has been felt. The want will be amply supplied this year; and advantage has been taken of the timber which several of the colonies are sending over to construct seats of colonial wood, which will serve the double duty of rests for the weary and objects of interest to those concerned in timber of all kinds. Amongst others, there will be seats of pine, from Queensland; of redgum, of iron bark and of blackwood, from South Australia; and of bluegum from Victoria.

INTERNATIONAL CONFERENCE ON MUSICAL PITCH.[*]

In November, 1885, the Austrian Government invited other Governments to send representatives to a Conference for the purpose of establishing a Universal Musical Pitch. The following delegates attended :—

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[*] Beschluesse und Protokolle der Internationalen Stimmton-Conferenz in Wien, 1885. Veroeffentlicht vom k. k. Ministerium fuer Cultur und Unterricht. Vienna, 1885. The Resolutions, as passed unanimously, are placed first and

Austria.—Baron von Bezecny, Honorary President; Herr Fidler, Chief of Department (Sections-chef), representing the Minister of Education; Dr. Hanslick, Professor at the University; Herr Hellmesberger, Conductor of the Court Band (Kapelle); Herr Jahn, Director of the Court Opera; Herr Komzak, Military Bandmaster, representing the War Office; Dr. von Stefan, President, Professor at the University; Dr. Zeller, Member of Council of Department (Sectionsrath), representing the Government, and Reporter; Herr Zellner, General Secretary of the Society of the Friends of Music (Gesellschaft der Musikfreunde).

Hungary.—Dr. Max Schuetz.

Italy.—Professor Pietro Blaserna, Vice-President; Maestro Arrigo Boito, composer.

Prussia.—Herr Blumner, Director; Herr von Bronsart, Intendant; Prof. Engel; Herr Joachim, Director, Vice-President; Prof. Koslek; Dr. Wueilner, Director.

Russia.—M. Grushka, Military Bandmaster; Prof. Leschetitzky.

Saxony.—Prof. Fuersternau, Dr. Reinecke, Conductor of the Band, (Kapellmeister), Herr Schuch Conductor of the Band.

Sweden.—Secretary Dr. Svedbom.

Wuertemberg.—Prof. Dr. Faisst, Herr Seifriz, Director of Court Music.

Secretary, Baron von Weckbecker, précis writer.*

A.—PRINCIPAL RESOLUTIONS.

The International Conference on Musical Pitch in Vienna, in its sittings of the 16th, 17th, 18th, and 19th November, 1885, unanimously adopted the following resolutions :—

I. There shall be one single International Normal Musical Pitch Note. This Normal Pitch Note shall be that A which is determined by 870 simple vibrations in a second [that is, the French *Diapason Normal* of 435 double vibrations in a second].

To represent this Pitch Note, a normal tuning-fork shall be constructed so as to give the normal note at a temperature of 15° Centigrade [= 59° Fahrenheit, as used in England, and 12° Reaumur, as much used in Germany, being the temperature for which the French *Diapason Normal* was constructed. Tuning-forks flatten on increase, and sharpen on decrease of temperature, by about 1 vibration in 20,000 for each degree Fahrenheit, or about 1 in 11,111, say 11,000, for each degree Centigrade. Hence the necessity of assigning the temperature. Harmonium reeds alter in the same directions to twice that extent].

For carrying out this resolution, which is indispensably necessary in the interests of practical musical cultivation, the Conference likewise unanimously recommends the following regulations to all Governments concerned :—

II. The acceptance and introduction of the normal pitch note shall be universal and obligatory. In especial it shall extend to all public and private educational establishments in which music is cultivated, and similarly also to musical societies, theatres, and so forth.

Military bands shall adopt the normal pitch as soon as possible, and at latest on the occasion of replacing the wooden wind instruments.

Similarly, the patrons and authorities of churches are to be influenced to make the pitch of their organs agree with the normal as soon as possible, and in any case on the occasion of rebuilding or general repairs.

III. Respecting the time within which the introduction of the normal pitch shall be completed, individual States should appoint the shortest possible interval.

IV. In order to preserve the normal pitch note from alteration, the following regulations shall be adopted : —

(*a.*) All establishments and bodies whose duty it is to accept the normal pitch, shall be responsible for the preservation of the pitch note correctly within the sphere of their action, and for that purpose must possess a verified tuning fork. Other sounding bodies, such as harmonium reeds, pitch pipes, and so forth, are declared unsuitable for the authentic reproduction of the normal pitch note.

(*b.*) Governments concerned shall subject the unaltered condition of the normal pitch note in all these establishments to a constant supervision, by properly appointed authorities.

(*c.*) Each State concerned shall appoint an office to preserve the normal tuning fork, to test all forks brought to it for verification, to set them right, and to authenticate them by a stamp.

(*d.*) Only such forks shall be declared suitable for testing and authenticating as satisfy the following conditions :—

- (*d.* 1.) The forks must be made of unhardened steel.
- (*d.* 2.) The prongs must be parallel, and at least half a centimetre [one-fifth of an inch] in breadth.*
- (*d.* 3.) The space left for the stamp, between the internal bend of the fork and the tang [or handle], must be at least a centimetre [two-fifths of an inch.]
- (*d.* 4.) The fork to be verified must be quite free from rust, and polished white, or blued.

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translated in full. The Discussions are given in abstract. The words in [ ] and the footnotes have been added by the Translator as elucidations. The report is published in the I. and R. School-book Depôt at Vienna.

* France, Spain, and Belgium, which had adopted the French pitch, were not represented. There was also no one from England, where the Government does not concern itself with music, except to grant capitation fees for singing in primary schools.

* This probably refers to the breadth across the prongs, not to their thickness. In that case, most ordinary tuning forks satisfy it; but it is quite a minimum size for a normal or standard fork.

(*e.*) The office of verification has to authenticate the correctness of the fork, first by the international stamp, consisting of the figures 870, enclosed in an ellipse; and secondly, by the stamp of the particular Government.

B.—Subsidiary Resolutions.

In order to preserve the normal pitch, all theatres and institutions for concerts are to submit to the following regulations:—

V. The wind instruments to be used at these institutions shall be tuned to the normal pitch at 24° Centigrade [= 74·4° Fahrenheit = 19·2° Reaumur]. Instrument-makers shall show, by an impressed factory pitch-mark, that they guarantee their instruments to have been thus tuned.

VI. The most suitable instrument to settle the proper tuning in orchestras, and hence to preserve the normal pitch, is a tuning-fork kept in motion by electricity. Where this is not in use, the oboe should not be employed for tuning from, until it has been thoroughly warmed. The conductor of the concert is responsible for the perfectly correct pitch of his orchestra.

VII. Organs shall be brought to the normal pitch at such mean temperatures as shall be suitable for the special circumstances under which they are used.*

VIII. The formation of centres for military music is absolutely necessary for the proper carrying out of the principal resolutions of the Conference, and shall, therefore, be undertaken as soon as possible.

First Sitting.

The Conference was welcomed on Monday, 16th November, 1885, by the Minister of Education, Dr. Gautsch von Frankenthurn himself, who, in a brief speech, partly in German and partly in French, said that his predecessor, Baron von Conrad, had caused full attention to be paid to the subject of their deliberations, and that the Austrian Government had called together an International Conference at the instance of the Society of Friends of Music, at Vienna, the Directors of the Court Palace Band (Hofburgkapelle), of the Opera, of the Burg Theatre, and of the Court Palace Music, and at that of that first Orpheonist Society, the Male Voice Choir (Maenner-Gesang Verein), believing that it was a question which could only be settled internationally.

The Minister having withdrawn, and the officers having been elected, Dr. Zeller, on behalf of the Government, introduced the motions that it was hoped would be passed. He said, confining himself to modern times, that the question had occupied the musical world for 200 years, instancing Praetorius, Mersenne, Sauveur, and Chladni. He then mentioned Scheibler's proposed A 440.* It was not, however, till 25 years later, in 1859, that a pitch was established by law in France. This first step was much followed. Belgium adopted it in 1863. But how unfortunate it was that France established a national instead of an international standard, was shown by Belgium having drifted up to A 451, from which it reverted to French pitch by royal decree on 19 March, 1885. In Austria, French pitch had been adopted in 1862, but in 1882-3 it had reached 441½ and 441. Measurements made a few weeks ago in the Court Opera at Vienna show 449 to 450 vib.† Italy did not adopt a uniform pitch. That adopted in 1884 applied to the army only, and selected as a standard B *flat* 456 vib. Hence we had only to deal with two fixed pitches, this and the French.

The Austrian Government thought it right to call a preliminary committee of experts, which Dr. Zeller joined on the part of the Government. This consisted of Baron von Bezecny (who presided after the death of Baron von Hofman); Ludwig Boesendorfer, pianoforte maker to the Court; Dr. Johannes Brahms; Nikolaus Dumba; Prof. Dr. Gaensbacher; Prof. Dr. Hanslick; Herr Helmesberger, Court Band Conductor; Herr Jahn, Conductor of the Court Opera; Herr Kremser, Choir Conductor; Herr Komzak, Military Bandmaster (especially representing the War-office); Prof. Dr. von Lang; Herr Hans Richter, Vice-Conductor of the Court Band; Herr Stecher, instrument maker; Prof. Dr. von Stefan, Herr Uhlmann, instrument maker to the Court; Herr Winkelmann, singer at the Court Opera; and Herr Zellner, General Secretary to the Society of the Friends of Music. To this committee Dr. Zeller paid a warm tribute.

The Government, fully a year ago, especially consulted the Society of Friends of Music in Vienna as to the means to be employed for securing an international pitch—(1) by the Legations in the form of inquiries; (2) by a commission regulating Austria alone. The first plan would lead to indefinite delay.

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* Organs vary greatly with temperature, sharpening by heat and flattening by cold, that is, in exactly the opposite direction from tuning forks, to an extent which may be found with sufficient correctness thus: To the existing pitch in double vibrations of an open metal cylindrical pipe at the existing temperature add 4 per cent., divide the result by 1,000 to 2 places of decimals, multiply the result by the number of degrees F. between the observed and required temperature and add to, or subtract from, the observed pitch. Thus, if the observed pitch at 39° Fahr. be 426, adding 4 per cent. or 17·04, we obtain 443·04, which, divided by 1,000, gives ·44304. To find the pitch at 59° Fahr. or 20° warmer, add 20 times this, or 8·86, and the result is 434·86, sufficiently near to the normal pitch, as organs are so extremely sensitive to temperature that they cannot be trusted to maintain their pitch exactly for an hour.

* All pitches were given in single vibrations, but are here translated into the double vibrations usual in England.

† Strauss's band from Vienna, at the Inventions Exhibition, used A 452. It is remarkable that at Vienna in 1814 musical pitch first began to rise in Europe, Mozart's pitch, A 421½, having been used up to that time; that in 1823 it was A 437½, according to Naeke, an excellent authority; that about 1834 Scheibler found pitches at Vienna varying from A 434 to A 441, on which was founded his proposal of A 440; that the old sharp Vienna pitch was A 456, and in performance even reached A 466, according to Naeke, in 1862; that it was then reduced to French pitch, and afterwards, as shown in the text, rose again to A 450, and yet that *no voice was raised the Vienna Conference in favour of a sharp pitch*, but that the whole controversy turned on A 435 and A 432.

The experience of France showed that only an international conference could succeed. No other ready way suggested itself, and how could a positive result be expected when France defended A 435, and Italy B *flat* 456?

The Italian pitch was meant to be Meerens's A 432, which was arrived at as the third perfect Fifth above C 64 on the violoncello, and for scientific purposes seems the best. If a standard had to be selected *de novo* it would be impossible to neglect the scientific basis on which Italy relies.* But the practical musician requires his tempered scale. He cannot comprehend the fuss made over a difference of 6 simple or 3 double vibrations between 435 and 432. He wants a pitch suitable to the singer, and then not a mathematical but a tempered scale. Now in this scale B *flat* 456 gives A 430·4 instead of A 432! Passing over further consequences, Dr. Zeller said that French pitch acquired its popularity from its being the first pitch settled by law. Hence in the Austrian preliminary committee even the representatives of physical science considered that a regard to circumstances (Opportunitaets - Ruecksichten) compelled them to adopt the French *Diapason Normal.*

Dr. Zeller proceeded in the name of the Austrian Government to move Res. I given above.

Prof. Blaserna explained in great detail the circumstances which decided Italy, after the Milanese congress in 1881, to accept A 432. He defended the scientific value of this pitch on account of easier calculation, more natural construction, and hence greater simplicity for theoretical instructions.† Nevertheless he declared himself authorised by the Italian Government to say that Italy had no objection to any other pitch beside A 432, provided that this other pitch were unanimously accepted, or at least had a sufficiently large majority. (Loud applause.)

Baron von Bezecny and Herr von Bronsart expressed their great satisfaction at this announcement, and the latter laid weight on the circumstances which gave A 435 the preference over the incontestable scientific advantages of A 432. Director Wuellner and Professor Engel agreed with the last speaker; but Maestro Boito dwelt on the scientific labours of Meerens and Sauret, and inveighed against opportunism, which in this case he considered an anachronism. Director Blumner and Dr. Wuellner opposed these views, and pleaded for French pitch. Director Seifriz, considering the question of cost entailed by the introduction of a lower pitch than the French, agreed with the last speakers. Dr. Svedbom, in the name of Sweden, said he should vote for French pitch. The discussion was continued by Messrs. von Bronsart, Blaserna, Faisst, and Engel, who mostly sided with the Government Representative.

Professor Von Stefan said the question did not turn upon having a pitch number easily divisible as 432;* that was merely an advantage to arithmetical esthetics, against which we must set, that French pitch was legally adopted in France, Belgium, and Russia,† that it was used in many Institutes in Germany, and generally in Austria. Conductor Hellmesberger proposed that, after hearing these opinions, voting on the pitch should be deferred till next day, with which Professor Blaserna agreed, but Professor Hanslick wanted to vote immediately, and Director Joachim thought that they might defer voting till next day, but proceed at once to consider other points. On taking divisions on these motions, the voting on pitch was deferred, and the present sitting closed.

Second Sitting.

On Tuesday, 17th November, President Prof. von Stefan gave a summary of the previous day's discussion, and considered that it was not necessary to put the first sentence of Resolution I. to the vote. But Herr Zellner proposed to prefix the following lines to the second sentence—

"Considering that although the choice of A 432 would offer a series of advantages which should not be undervalued, both for the theory and practice of music, yet, after the position assumed in many countries in respect to this subject, and especially after the gratifying manner in which the Italian Government had met the other view, French pitch appears now to be the only one fitted to become an international pitch, the Conference resolves that, &c.," as in Res. I.

Director Joachim thought that such an introduction would impair the force of the resolution. It was absolutely impossible to say that one pitch note was decidedly the best, and then select another. Prof. Hanslick agreed with this view. Prof. Blaserna merely wished that it should appear in the resolution or elsewhere, that the Conference had seriously considered the pitch A 432, as this would strengthen the hands of the Italian Government in the indirect pressure upon theatres which was all they could exert.

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* No one seems to have remarked that A 432 is not even scientifically good, for it is obtained from C, and yet is not the A of the key of C, for that in just intonation should be A 426⅔, that is a comma flatter, and in equal temperament A 430·6. Nor is there any but an arithmetical advantage is having C 64, 128, 256, and this is broken by an infinitesimal deviation from exactness, while in practical tuning the deviation is always much more than infinitesimal. For a tempered scale moreover, A 432 gives B *flat* 457·7 and not 456 as was adopted in Italy, while B *flat* 456 gave A 430·4, as stated in the text, so that the result was a confusion in every way. By a misprint in the German, the violincello C is made to have 164 in place of 64 vib.

† In the *Rendiconti* (proceedings) of the *Accademia dei Lincei*, at Rome, for 6 December, 1885, Prof. Blaserna, who is the secretary, gives an account of this Conference, and devotes the latter part of his paper to showing that Meerens's A 432 has *not* a scientific foundation, although he does not adduce the points mentioned in the last note.

* He meant divisible by 2 for the Octave, this does not apply to 432, which gives 216, 108, 54, 27 and there stops, although that is lower than any note usually employed; but he was no doubt thinking of the 128, 64, 32, 16, 8, 4, 2, 1, whence the 432 was derived.

† And in Spain on 18th March, 1879.

The President remarked that though at first only the bare resolutions would be published, copies of the reports of the meetings would be sent to all governments, and thus Italy would see all that had been done; but to meet Prof. Blaserna's views he proposed that "the Austrian Government be requested to inform the Italian Government that the Conference fully and thankfully appreciated the way in which the Italian representatives had met their views; that they had accurately and maturely considered the advantages of the Milanese pitch, but, nevertheless had resolved, for cogent reasons, not to adopt it."

Conductor Hellmesberger warmly seconded this proposal, Professor Blaserna and Maestro Boito were satisfied, and it was agreed to. Then Herr Zellner's introduction becoming superfluous, the two first clauses of Res. I. were put and carried unanimously amid much applause and cries of "Bravo!"

The third paragraph of Res. I. was then agreed to, with a trifling change, which occasioned some debate. Prof. Blaserna proposed that after "870 simple vibrations" should be inserted or "435 complete vibrations." The consideration of this point was deferred, and, ultimately, the addition was rejected.

On Res. II., par. 1, much debate arose on account of the expense that would be occasioned, but Dr. Zeller showed that it was a logical consequence of Res I. In par. 2 there had been a permission for a time to use a tempered B *flat* pitch note of 460·9 vib., to be called A, and hence to make the pitch a semitone higher than French pitch, but this was struck out, and the whole resolution agreed to.

In Res. III. there had been a clause fixing the time for the introduction of the normal pitch to one year for Vienna, and two years for the rest of the empire, without prejudice to the latitude allowed for military instruments and organs; but this not being international, was omitted, and then Res. III. was agreed to as above.

Res. IV., pars. *a* and *b*, were agreed to without change; *c* with a merely verbal change; *d*, 1 and 2, as they stood. The next had originally run thus:—

> "(*d*. 3.) The tang [handle] must be cylindrical throughout, and may be provided half way up with a screw-worm, if desired.
>
> "(*d*. 4.) The space left for the stamp, between the internal bend of the fork and the tang, must be at least one centimetre.
>
> "(*d*. 5.) The fork must be tuned as near as possible to the normal pitch note, and polished white, or blued.
>
> "(*d*. 6.) The mark of a verified fork shall consist:—(1.) In its having the stamp of the proper office; (2.) in being blued after verification; and (3.) in showing no white file mark.
>
> "(*d*. 7.) As a uniform mark of verification, a Latin A within a circle = A orbis, was proposed to the Conference; but the individual States should be permitted to have a particular mark to show their own action."

This gave rise to much discussion. Professor Blaserna having shown that the form of the handle, and the screwing of a fork on a resonance box, only influenced the length of time for which a fork vibrated, and not its rapidity; on the motion of Director Joachim, *d*. 3. above was omitted; *d*. 4. was retained almost unaltered. On a motion of Professor Blaserna in the following sitting, *d*. 5. was slightly altered. On the motion of Professor Blaserna *d*. 6. was entirely omitted. The form of the mark was altered, as all nations do not call the note A [the French call it *La*]. The use of D N (for diapason normal) was proposed and rejected, and the number 870 in an ellipse chosen. A sub-committee was appointed to prepare the subsidiary resolutions B.

Third Sitting.

On Wednesday, November 18th, the details of Res. IV. were again considered, and, finally, it was unanimously passed, as given at the beginning of this report.

Much discussion arose respecting Res. V. as to the proper temperature, but it was finally adopted as at the beginning.* In Res. VI. the electric-motive system of Herr Zellner was mentioned, but it was objected that this might be improved, and the name was, therefore, omitted.†

For Res. VII. it was found impossible to fix a temperature of tuning for organs in different countries (such as Sweden and Italy), and at different seasons. This was, therefore, left to the discretion of the tuner. An attempt to fix the pitch for which pianofortes should be tuned failed, although Herr Schuch, warmly seconded by Professor Engel, insisted that this should be the case for those used in teaching singing, and the sitting closed.

Fourth Sitting.

The fourth and last sitting took place on Thursday, 19th November, 1885. Res. VII. was reconsidered. Dr. Wuellner considered that this was not yet satisfactory, and Dr. Faisst and Prof. Blaserna warmly agreed. Dr. Faisst read a detailed motion on organs, with and without orchestral accompaniments, and used in warmed or unwarmed spaces. Herr Zellner wished concert organs to be treated as orchestral instruments, and hence to be excluded from

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* The rule probably means that the wind instrument at 24° C is to give the note A of the pitch of the tuning fork at 15° C. Thus, when the instrument gets warmer as the concert proceeds, its pitch will be only slightly too high. Whereas, if it were tuned when cold, it would become very much too sharp.

† Herr Zellner informs the Translator that his electrical tuning fork was shown in action to the Conference, and has been adopted by the opera houses in Vienna, 'Pesth, Berlin, Dresden, Stuttgart, Leipzig, and the Conservatories of Music in Vienna and Berlin, and the Berlin "Sing-academie." In its absence a loud reed freshly tuned by 3 beats in a second above a fork 3 double vibrations too flat, and kept in action by a constant blast, would certainly be effective.

Res. VII.; church organs should be tuned at 15° C.[*] Prof. Engel considered that the great diversities of climate precluded any temperature being named. Prof. Koslek was for giving up Res. VII. Further discussion on the temperature in Res. V. ensued. Prof. Blaserna considering that 20° C. better represented the mean, but Herr Von Bronsart said it was better to begin too low and sharpen to pitch, than to begin right and sharpen afterwards. Res. V. remained unaltered, and Res. VII., as given above, passed unanimously.

Dr. Zeller then proposed that, in accordance with a resolution of the Preliminary Committee, the harmonium should be used in place of the violin for giving instruction in singing. Dr. Svedbom said the harmonium was almost universally used in Sweden. After objections by Prof. Engel, Dr. Faisst, Dr. Wuellner, and Herr Joachim, Dr. Zeller said that he had sufficiently discharged his duty to the Preliminary Committee by bringing their proposal forward, and asked leave to withdraw it.[†] And he then introduced the question (discussed in the Preliminary Committee) of a uniform naming of the Octaves, the 32 foot Octave being the first, the 16 foot the second and so on, but it was settled that this lay out of the province of the Conference.[‡]

Dr. Zeller then proposed Res. VIII. for the purpose of controlling military music, which plays such an important part in all countries. The resolution met with much applause and sympathy, and was unanimously adopted. This finished the proper business of the Conference, but on the written request of the Wuertemberg Government for an examination of the proper construction of tuning forks, and the measurement of pitch, the President called on Herr von Stefan, who read a short paper on the subject to the following effect:—

The points to be aimed at in the construction of tuning forks are—(1) invariability of pitch, (2) length of time of audible vibration, (3) adaptability for the optical methods of examination.

(1.) This depends on inalterability of mass, form, and elasticity. Cast steel is best for these purposes. Gilding protects forks from chemical injury.[*] According to Koenig, in 1878 the Paris diapason was 0·45 vib. too sharp, and according to Mr. H. Wild, the St. Petersburg fork was 0·2 too sharp in 1883. Whether these were original or subsequent errors cannot be determined.[†] A tuning fork alters more at first than afterwards, hence the same precautions must be used as in determining the zero point of thermometers. As frequent use probably affects the elasticity; forks for verification should not be be compared with the original standard, but with an auxiliary fork.[‡]

(2.) This is best reached by having the prongs uniform throughout, parallel, and considerably far apart. The vibrations of a tuning fork are diminished in duration by a resonance-box, and the more so the more accurately the box is turned to it, and if it is not tuned to it, the pitch is altered, although to an extremely small extent. Hence the standard tuning fork should not be placed on a resonance-box. A resonator to be used by the ear may be added, but it should not form a part of the stand of the fork. This has been disregarded in the standard forks hitherto constructed.[‡]

(3.) The optical method gives the surest result. But it is not safe to use a separate mirror. Hence the outer extremities of the prongs for at least a centimetre [two-fifths, or, say, half of an inch] should be brightly polished. A single bright spot would suffice for the use of the vibration-microscope. Former standard forks have not been adapted for this examination, as was felt very unpleasantly in the examination of the St. Petersburg fork in 1883. The optical method is closely connected with Koenig's tuning-fork clock. He concluded by recommending for immediate use Koenig's forks of 870 simple vibrations at 15° Centigrade, as he had found them very accurate.

The Resolutions were then read over to be formally passed, and it was determined that in Res. I., "870 simple vibrations," and not "435 complete vibrations," should be used, because the expression was quite unambiguous. [§]

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[*] This is seldom possible, but if the temperature is observed, the pitch of the pipe at the existing temperature that should give A 435 at 15°C, could be calculated for that temperature by the rule already given, and the pipes tuned to that, and thence the whole organ tuned. Suppose the temperature were 80° F., then an A 435 pipe at 59° F. = 15° C., would shew 445 vib., and the A pipe at 80° F. should be tuned to such a fork. The tuner would be provided with about a dozen forks about 4 vib. apart, and of known pitches. This pipe being properly tuned, the rest are easily adjusted by the rule in Ellis's Helmholtz, 2d. ed., p. 489.

[†] Both the Tonic Sol-fa College, and the promoters of the French Chevé system of teaching singing, find that purity of intonation is best reached without any accompaniment. The violin, generally used in Germany, may be played much out of tune.

[‡] The designation of the Octaves by the old foot-length of their longest pipe is already in general use, and was employed in the text. If this number of feet is prefixed to the name of each note in the Octave, as in Ellis's "History of Musical Pitch," notes can be perfectly represented; thus the tuning A 435 is 2 A, or A in the two foot Octave.

[*] The Diapason Normal at Paris is gilt. It is now much the custom to plate with nickel. Both processes are apt to slightly affect the pitch after tuning, and if they are subsequently filed, the protection is lost. But this is only for philosophical purposes requiring much greater accuracy than is attainable in music.

[†] There is every reason to believe that the pitch of Scheibler's tonometer remained absolutely correct from 1837, his death, till it was examined in 1880. See Ellis's "History of Musical Pitch," art. 18.

[‡] Greatest accuracy would be attained by making this auxiliary fork about 3 vib. too flat, the exact difference being determined by beats. The fork to be verified should then be made that number of beats in a second, counted through 10 or 20 seconds, sharper than the auxiliary fork. The unison itself could not be determined nearly so closely except by an optical method, which involves delicate apparatus.

[§] The method of reckoning simple vibrations is founded on the swing of the pendulum, and is scientifically accurate only for the vibrations of simple tones. In all compound tones, The rest of the sitting was occupied in formal votes of thanks to the Officers, the Minister of Education, the Government, and the Emperor.

ALEX. J. ELLIS.

Correspondence.

TIDE PREDICTING MACHINE.

I regret that I should inadvertently have appeared to commit myself to the statement that Mr. Roberts is the inventor of the tide predicting machine. I called it Roberts's because it was exhibited as his at the Inventions Exhibition, and because it was described as his in the number of the *Engineer* to which I referred for details. I regret this the more, because the question of priority, &c., was raised in the discussion on the paper of Sir William Thomson, read before the Institution of Civil Engineers on March 1st, 1881. Without wishing to raise this question, I may say that I should also have mentioned the names of Sir William Thomson and Mr. Beauchamp Tower, and not that of Mr. Roberts alone.

C. V. BOYS.

SLIDE RULE.

Mr. Beauchamp Tower writes to correct a mistake in the report of his remarks on p. 387, col. 1; line 10 should read—"*two* minutes in a week," instead of "one minute." The paragraph commencing "The slide rule" (ll. 13-17) should read—"The slide rule gave a uniform degree of accuracy in all parts of its scale, the distance between the divisions is inversely as the numbers, for instance, the distance betweeen 90 and 100 is very nearly the same as that between 10 and 11, so that an error of reading of such a dimension as to represent an inaccuracy of, say, 1 per cent. in one part of the scale, would give an inaccuracy of 1 per cent. in every part of the scale."

MEETINGS OF THE SOCIETY.

ORDINARY MEETINGS.

Wednesday evenings, at Eight o'clock:—

MARCH 17.—"Eastern Carpets." By VINCENT J. ROBINSON. Sir GEORGE BIRDWOOD, M.D., C.S.I., will preside.

MARCH 24.—"Domestic Electric Lighting." By W. H. PREECE, F.R.S. Sir FREDERICK ABEL, D.C.L., C.B., F.R.S., Chairman of Council, will preside.

FOREIGN AND COLONIAL SECTION.

Tuesday evenings, at Eight o'clock:—

MARCH 23.—"Canada and its National Highway." By ALEXANDER BEGG. Sir CHARLES TUPPER, K.C.M.G., will preside.

APRIL 13.—"The Progress of the British Possessions in the last quarter of a century." By P. L. SIMMONDS.

APPLIED CHEMISTRY AND PHYSICS SECTION.

Thursday evenings, at Eight o'clock:—

MARCH 25.—"Certain Methods for the Utilisation of Refuse and Dust Fuels." By WALTER G. MCMILLAN, F.C.S., Demonstrator of Metallurgy, King's College, London.

APRIL 8.—"Asbestos and its Applications." By JAMES BOYD.

MAY 13.—"The Scientific Development of the Coal Tar Colour Industry." By Professor R. MELDOLA, F.C.S.

INDIAN SECTION.

Friday evenings, at Eight o'clock:—

MARCH 19.—"Experiences on the Afghan Frontier." By WILLIAM SIMPSON.

APRIL 2.—"The History of Archæology in India." By JAMES GIBBS, C.S.I., C.I.E., late Member of the Viceroy's Council. Sir GEORGE BIRDWOOD, C.S.I., Member of the Council, will preside.

MAY 7.—"Indian Manufactures from a Practical Point of View." By B. H. BADEN POWELL, C.I.E. The Right Hon. Lord HARRIS will preside.

MAY 21.—"Everyday Life of Indian Women, as revealed in their own sayings." By Capt. RICHARD CARNAC TEMPLE.

The above dates are liable to alteration.

CANTOR LECTURES.

The Fourth Course will be on "Petroleum and its Products." By BOVERTON REDWOOD, F.C.S.

Lecture II.—March 15.—Production, Transportation, and Storage of Crude Petroleum. Well drilling. Use of the Torpedo. Pipe-line system. Bulk Transportation.

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the vibration one way and the return the other do not take place in the same time, though the sum of the two times is constant. This points out the double or complete vibration as being the proper one to be used. But as in practice the number of simple vibrations in a second is always taken to be double that of the complete vibrations, no error, although in some matters considerable inconvenience, arises from the use of simple vibrations.

Lecture III.—March 22.—Manufacture of Petroleum Products:—Naphtha, Burning Oil, Lubricating Oil, Paraffin. Methods of distillation and purification. Barrel and case making. Testing:—Flashing point, viscosity, lubricating power, melting point.

ADDITIONAL LECTURES.

Six Elementary Lectures on "Electricity" will be delivered by Professor GEORGE FORBES, on Saturday afternoons, at Three o'clock:—

Lecture I.—April 3.—Electromotive Force and Potential.
Lecture II.—April 10.—Currents and Resistance.
Lecture III.—May 1.—Magnetism.
Lecture VI.—May 8.—Electro-magnetic Phenomena.
Lecture V.—May 15.—Induction.
Lecture VI.—May 22.—Electrical Measurement.

Tuesday evenings, at Eight o'clock:—

"Japanese Art Work." BY ERNEST HART.

Lecture I.—May 4.—Japanese Metal Work.
Lecture II.—May 11.—Japanese Porcelain and Pottery.
Lecture III.—May 18.—Japanese Picture Books and Drawings.

The rules of admission to these Lectures will be the same as for the Cantor Lectures. Each member has the right of admission for himself and one friend.

Tickets available for all the Society's meetings were supplied to all the members at the commencement of the Session.

MEETINGS FOR THE ENSUING WEEK.

MONDAY, MARCH 15...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. (Cantor Lectures.) Mr. Boverton Redwood, "Petroleum and its Products." (Lecture II.)

Chemical Industry (London Section), Burlington-house, W., 8 p.m. Adjourned meeting on Mr. T. B. Lightfoot's paper, "Ice Making and Cooling Machinery."

British Architects, 9, Conduit-street, W., 8 p.m. Mr. J. B. Gass, "Some American Methods."

National Indian Association, Willis's-rooms, St. James's, S.W., 4 p.m. Annual Meeting, under the presidency of H.R.H. the Duke of Connaught.

Medical, 11, Chandos-street, W., 8½ p.m.

Asiatic, 22, Albemarle-street, W., 4 p.m.

Victoria Institute, 7, Adelphi-terrace, W.C., 8 p.m. Mr. F. A. Allen, "The Negro and Negroid Races."

TUESDAY, MARCH 16...Royal Institution, Albemarle-street, W., 3 p.m. Prof. A. Gamgee, "New Function of Circulation." (Lecture II.)

Civil Engineers, 25, Great George-street, S.W., 8 p.m. 1. Discussion on Mr. Dugald Clerk's paper, "The Explosion of Homogeneous Gaseous Mixtures." 2. Three papers on "The Economical Construction and Operation of Railways in newly-developed Countries, or where small returns are expected." By Mr. Robert Gordon, Mr. J. R. Mosse, and Mr. G. C. Cuningham.

Statistical, School of Mines, Jermyn-street, S.W., 7¾ p.m. Mr. Stephen Bourne, "Foreign and Colonial Tariffs as Influencing Prices and Affecting Trade."

Pathological, 53, Berners-street, Oxford-street, W., 8½ p.m.

Zoological, 11, Hanover-square, W., 8½ p.m.

WEDNESDAY, MARCH 17...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. Mr. Vincent Robinson, "Eastern Carpets."

Meteorological, 25, Great George-street, S.W., 7 p.m. 1. Mr. William Ellis, "Brief Historical Account of the Barometer." 2. Exhibition of Barometers and other Instruments invented during the past year.

Patent Agents, 55, Chancery-lane, W.C., 7½ p.m. Discussion on papers by Mr. Hardingham and M. de Pass.

Huguenot Society of London, Criterion, Piccadilly, W., 8 p.m. Mr. G. H. Overend, "The Field Preachings at Antwerp in 1566, with some account of the erection of Protestant Temples in that City."

Archæological Association, 32, Sackville-street, W., 8 p.m. 1. Mr. W. de Gray Birch, "Legendary History of St. Nicholas of Myra." 2. Mr. Thos. Morgan, "Notes on Haslemere."

THURSDAY, MARCH 18...Royal, Burlington-house, W., 4½ p.m.

Antiquaries, Burlington-house, W., 8½ p.m.

Linnean, Burlington-house, W., 8 p.m. 1. Mr. Wm. Fawcett, "New Species of *Balanophora* and *Thonningia*." 2. Prof. P. M. Duncan, "Madreporia of the Mergui Archipelago." 3. Mr. C. B. Clarke, "Botany of the Naga Hills."

Chemical, Burlington-house, W. 8 p.m.

Society for the Encouragement of Fine Arts, 3, Conduit-street, W., 8 p.m. Mr. Herman Merivale, "The Drama of the Day."

Parkes' Museum of Hygiene, 74A, Margaret street, W., 8 p.m. Captain M. P. Wolff, "The Rational Alimentation of the Labouring Classes."

Royal Institution, Albemarle-street, W., 8 p.m. Prof. W. Boyd Dawkins, "The Ancient Geography of Britain." (Lecture III.)

Historical, 11, Chandos-street, W. 8 p.m.

Numismatic, 4, St. Martin's-place, W.C., 7 p.m.

FRIDAY, MARCH 19...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. (Indian Section.) Mr. William Simpson, "Experiences on the Afghan Frontier."

United Service Institute, Whitehall-yard, S.W., 3 p.m. 1. Colonel J. B. Richardson, "The 'Weldon' Range-finder." 2. Mr. Arnulph Mallock, "The 'Mallock' Range-finder."

Royal Institution, Albemarle-street, W., 8 p.m. Weekly Meeting. 9 p.m. Mr. W. H. M. Christie, "Universal Times."

Philological, University College, W.C., 8 p.m. Dr. Whitley Stokes, "The Old Breton Glosses at Orleans."

SATURDAY, MARCH 20...Geologists' Association, University College, W.C., 2½ p.m. Visit to the Science Schools, South Kensington. Demonstration by Professor Judd.

Royal Institution, Albemarle-street, W., 3 p.m. Mr. E. B. Poulton, "The Nature and Protective Use of Colour in Caterpillars." (Lecture II.)

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FRIDAY, MARCH 19, 1886.

All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

NOTICES.

CANTOR LECTURES.

The second Cantor Lecture on "Petroleum and its Products" was delivered by Boverton Redwood, F.I.C., F.C.S., on Monday evening, 15th inst. The lecturer gave a detailed description of the methods adopted in obtaining the crude petroleum in various countries, contrasting the laborious operation of excavating the wells by hand, which is practised in Japan, with the comparatively expeditious system by which, in the United States, wells are drilled to a depth of as much as 2,400 feet. The process of drilling with a "string" of tools nearly 60 feet in length and weighing about 2,000 lbs. was described, and the difficulties and dangers attending the various operations were enumerated. The "torpedoing" of wells to increase their productiveness was also referred to, and it was incidentally mentioned that no less than 8 tons of nitroglycerine were used for this purpose in the Bradford field during the month of July last. The latter part of the lecture was devoted to a description of the methods of transportation and storage. The trunk lines of the National Transit Company, in the United States, conveying the crude oil from the wells to the refineries, were stated to be of the aggregate length of 1,330 miles, the line from Olean to New York having a length of 300 miles, with 11 pumping stations; the greatest elevation above tide-water being 2,490 feet and the capacity of the line 28,000 barrels per day, under a working pressure of 900 lbs. per square inch. The lecture was illustrated by a number of models and a series of lantern photographs.

The lectures will be published in the *Journal* during the autumn recess.

Proceedings of the Society.

FIFTEENTH ORDINARY MEETING.

Wednesday, March 17, 1886; Sir George Birdwood, M.D., C.S.I., in the chair.

The following candidates were proposed for election as members of the Society:—

Dunn, John, 1, John-street, St. James's-square, S.W.
Greenman, Charles, 76, Clayton-road, Peckham, S.E.
Robinson, Edward A., Combe Down, Bath.
Storey, H. S., Lancaster.

The following candidates were balloted for and duly elected members of the Society:—

Blythe, Herbert, Church, Lancashire.
Brookes, Thomas William, The Grange, Nightingale-lane, S.W.
Brown, William A., Cliff Lodge, Greenock.
Field, George W., 23, Park-street, Park-lane, W.
Peter, Otho Bathurst, Northernhaye, Launceston, Cornwall.
Tate, Edwin, 21, Mincing-lane, E.C.
Thompson, James Elliot, Thornhill-park, Sunderland.

The paper read was—

EASTERN ART CARPETS.

By Vincent J. Robinson.

The approach to our subject can only be made through a short avenue of historic fact. Woollen manufacture in some form is of the highest antiquity, and was probably one of the very first which man contrived for his personal comfort.

In the pastoral life of Central Asia, illustrating the commencement of civilisation, flocks of sheep and goats furnished the skins used by the nomads for covering both their bodies and the floors of their tents. As civilisation progressed, the tribes under the patriarchal life represented in the Bible had invented the arts of weaving and of dyeing, had begun to remove the fleece from the skin of the animal whilst still living, and to contrive clothing, and, finally, hangings and carpets, for their tents. The women of the tribes, who drove their flocks from pasture to pasture, had then, as they have at the present day, abundance of leisure, and the most exquisite wool with which to work their devices. It was under these conditions that the art of carpet weaving began.

The designs used now are doubtless those in use in the time of Abraham, and probably for centuries before. Peculiar and distinguishing patterns marked the work of each tribe, and by these patterns it is to this day often possible for the expert to determine the district whence particular carpets have originated. Such testimony from written sources of information alone would hardly suffice to identify any details with precision. Fortunately, we have in Egypt tombs and mural graphic evidences which, taken in conjunction with other facts, enable us to form a tolerably accurate idea of the antiquity and distribution of these arts. The earliest indication of the actual operation of weaving is, I believe, depicted in the tomb of Beni Hassan, which carries us back to 3000 B.C. This painting shows two figures at work at a loom, precisely like those now in use all over the East, and resembling the "Haute Lisse" still employed for tapestry in Europe.

The Egyptians were only able to work with lines or checked patterns, any further ornamentation had to be added with the needle. At what time the pile or plush-like surface was introduced into weaving there is no evidence to show, but the Egyptians appear to have used it, and in speaking of carpets as distinct from tapestries, we may regard this as a distinguishing feature.

The earliest floor coverings of which we have pictorial record are those indicated in the pavements of the palace at Nineveh, where the practice of dividing the interior of buildings by means of hangings or drapery, which in later times were replaced by solid walls, may be compared with the treatment of the floor spaces. A carpet was spread for the occupants to sit upon. Subsequently the design of the carpet came to form a part of the permanent pavement, and this was shown by inlaying it with coloured tesseræ.

Admitting this evidence as to the use of some kind of carpet like those on the pavement at Nineveh, we conclude that carpets for the floors of buildings existed before the 8th century B.C.; and they probably were of the kind still made in Syria, and known by the term "Geleem," being woven in a peculiar manner, limiting the pattern to geometric forms with varied colouring. The designs on the pavement are those of some of the carpets still in use in Syria.

Babylon was, however, the great centre of textile manufactures, and is referred to as the place renowned for woven and embroidered fabrics in the highest perfection, and for all the varieties known in ancient times among Asiatic nations. As proof of the high estimation in which Babylonian work was held, Plutarch mentions that Cato having received a Babylonish garment as a legacy, sold it, as being too costly for a citizen to wear.

The use of gold thread in the weaving of their stuffs originated there, and they excelled in what are described as cloths of divers colours, as well as in embroidery work. (Pliny, viii., 48; Ezekiel, xxvii., 24, B.C. 500; Joshua, vii., 21, B.C. 1427). They also appear to have introduced for ornamental purposes the figures of birds and animals, as, for instance, the cheetah, or sporting leopard; the homa, or tree of life. They also made use of symbolic forms, like the two-handled vase, although this is, strictly speaking, Jewish.

It was in Babylon that those manufactures took their rise, which have been carried on in succeeding ages in the countries between the Persian Gulf (or, rather, the Suleiman range of mountains) and the Mediterranean: certainly the most conspicuous features of mediæval Persian work were derived thence. The carpets of Babylon were as highly prized as their other manufactures. The prosperity of the city probably decayed before our era, since Pliny says that the manufacture of carpets was carried on by the Parthians. (i., viii., c. 73.) Some remains, however, lingered on the Euphrates, for the looms of Arech were long celebrated, and it is not unlikely that the carpets so much valued by the Greeks, and subsequently by the Romans, were made there. It is certain that the traditions remained in Baghdad in the time of the Caliphs, and so late as the 15th century of our era some kind of carpets were made by the monks in a Christian monastery near Mosul.

The manufacture of Babylonian carpets, as we have seen, was carried on by the Parthians; later on the Milesians are spoken of as conspicuous in connection with them. Aristophanes, writing in the 5th century B.C., mentions Milesian fleeces. The people of Sybaris wore garments of Milesian wool, and Phylarchus says there was a law exempting the importers from all taxes. In England we are said to be on the way to becoming Sybarites, but carpet importers may look in vain for such privileges, even from a Liberal government. Aristophanes also says the Greeks brought from Ecbatana, in Medea, winter clothing covered with long tufts (Vesp. v., 1132), which I take to mean material covered with pile; this is probably the first notice we have of it. Thus we trace the spread of woven productions westward. Sardis manufactured carpets, and Cyprus was renowned for embroideries; the Coraxi, on the Euxine, or Black Sea, becoming noted as time went on.

These people are probably the modern Caratshai of the Caucasus, and we thus identify so much of antiquity for those beautiful rugs which are commonly called Daghastan, with which Europe was recently flooded for three or four years, and of which genuine specimens are no longer to be had.

The Greeks seem never to have had any considerable woollen manufactures of their own; their genius was probably unsuited to such pursuits. They admired whilst they depended for their supplies upon the Easterns, whom they most inconsistently stigmatised as barbarians.

So far as concerned textiles, the Greek colonists in Asia Minor did little more than transport the productions of the countries which they colonised. That carpets were used in Greece for their floors, and for putting under couches, is certain from many passages in their authors. Xenophon remarks, "They even put the feet of their couches on carpets, to prevent resistance from the floor, that the carpets may yield to it." And Cleitus, a friend of Alexander, used to walk about on a carpet whilst talking to those who came to see him.

The admiration of the Greeks for Eastern textiles was handed on with other luxuries to Rome, and we have in Latin authors an increasing number of allusions to the subject.

After the Roman conquests in Persia, all that group of manufactures hitherto known as Babylonian, Parthian, &c., are now referred to under the designation Persian, by which name they may be said to be known all through the middle ages to this day. For instance, in 280 B.C., Callixenus describes the pavilion of Ptolemy Philadelphus with carpets of finest wool with pattern on both sides, and thin Persian cloths having representations of animals embroidered on them. In this feature of animals either woven or embroidered on carpets and other fabrics, we notice the old Babylonian traditions, which remained in favour with the Persians through mediæval times, and continued to this century—affording a very remarkable instance of the continuity of Eastern traditions. The Romans greatly valued Eastern fabrics, and some they bought for their weight in gold. The sums paid for beautiful productions may be realised from what Pliny says about Nero, who paid four millions of sesterces (about £33,000), for a Tricliniaria Babylonica.

With reference to these Tricliniaria Babylonica, Sir George Birdwood, in his preface to my book on Eastern carpets, gives a quite original and no doubt perfectly truthful derivation of the Kinari carpet of the Persians, which to this day they use in the same form as the Tricliniaria Babylonica of the Romans.

Pursuing the history of carpets into India, we are met by a profound obscurity, for until comparatively recent times, namely, until the 10th century of our era, India may be said to have no history of its own, unless the very meagre facts furnished by its epic poems may supply its place.

In the Mahâbharata and the Ramáyana, which contain incredible descriptions of impossible events, there are a few notices of textiles and of colours. Beyond this we have only a few Buddhistic inscriptions at wide intervals of time, of the reign of Asoka, which was supposed to have dated a little earlier than the time of Alexander the Great. These are all the data we have by which to fix early Indian chronology. India is supposed to have derived her arts from the valley of the Euphrates; but we only know that there was a regular trade route between those countries through Saba and Dada on the Arabian coast (Isaiah xl., 6; Ezekiel xxvii., 15, 20); then through Gerrhei (Diod. iii., 41, Strabo 15), and finally by Kenar (Isaiah xl., 7).

About 1400 B.C., the Mahâbharata describes the coloured garments worn by men and women, and, later, about 540 B.C., the first synod of Buddhistic monks was held, in which they arranged themselves according to rank, dressed in yellow robes, the colours being precisely those which now distinguish the religious orders of Hindoos and Buddhists.

The kind of dresses worn in the 6th century A.D. may be seen in the rock-cut temples of Ajunta, and they possibly did not much differ during the centuries from 200 B.C. to 800 A.D. But we have from these sources no trace of carpets. There is reason to believe that 2,000 or even 3,000 years ago, the Indians had attained a higher state of refinement than they now possess. The traveller through the Carnatic or Mysore is struck with innumerable proofs of there having been a time when those regions were the nursery of the fine arts. Indeed, the peninsula from the Ganges to Cape Cormorin abounds with marks of antiquity, arts, science, and civilisation.

We may infer that at no period of their history could a Rajpoot chief have been unable to write his name, or even to have celebrated his own achievements in verse.

With the slender materials at our disposal, we cannot discover when carpets came to form one of their luxuries. The Mahommedan conquest may, however, be taken as the epoch when India, in her North-West and Central Provinces, underwent profound modifications. The provinces to the south of Nerbudda, which had been conquered by the Hindoos at the time corresponding to the beginning of the Christian era, were very little affected by the Mahommedan invasion, and the caste system introduced by the Hindoos, with all the attendant influence on the relations of life and its occupations, remained, until quite recently, almost undisturbed. And it is in the southern part of India that we have Hindoo designs in their integrity, bold and vigorous in colour, geometric in form.

In considering the origin of woollen manufactures, Nature seems herself to have defined the districts in which we might expect it to have arisen.

As no bones of the sheep have been found in the caves of Europe, it is probable that the animal was not native there—indeed, it would appear to have been indigenous to Central Asia. There the nomadic tribes had large flocks and herds, although, according to Justin, they were ignorant of manufactures. This would apply only to very early times. But though India possessed sheep, there is no proof that wool was used. Cotton and other vegetable substances were invariably employed for weaving. Central Asia being the chief point, breeding of the animals spread thence west and south across the Himalayan range into India, where some of the favourable conditions reappeared at intervals in the tableland of that Peninsula.

In Rajpootana, and along the Neilgherries, in the Deccan and in Malabar, vast tracks of land support immense flocks of sheep, producing wool of every quality except the finest. The very finest wool, called *put*, is only to be found in Turkestan, at Bokhara and Samarkund. This is the undergrowth which appears only in the cold season. The fleece is shorn, and the *put* combed from the under part of it. Cashmere takes this wool for her shawls. About Cabool and Moultan carpets of small size were formerly made from the refuse portions of *put*, but the competition of the Government goals has quite destroyed the industry.

In Afghanistan, and westerly at Khorassan, and about Shiraz and Kerman, similar conditions led to like results. In the mountain ranges, having an altitude of 4,500 feet about Shiraz, 7,600 feet around Herat, some of the best wool in the world for carpet purposes is grown, and it was from this material that those 16th century carpets were made. The wool was lustrous and soft, of a texture produced by the sweet pasturage on which the sheep fed. In some of these districts the animals are covered with cloths, to protect and give greater softness to the fleece. The sheep, with large tails, to which reference is made by Ctesias, were not of Indian but either of Persian or Arabian breed, and the tails are now used for the manufacture of Persian hats. These sheep are shorn twice a year, and the value of the finest wool, as I understand, is about 10s. 6d. per lb., inferior kinds descending to as little as 4d. per lb.

In the lower and hotter altitudes the wool is shorter and the staple coarser, not so lustrous, and not so well adapted for carpet manufacture. These varieties can only be used by mixture in the manufactures of coarser quality and bolder designs.

Carpets combining these conditions, unrivalled for effective decoration, were formerly made about Hyderabad, in the Deccan and in Scinde, and the North-West Provinces; but, like so many other native industries, the action of the Government has doomed them to extinction. In the more inaccessible mountain ranges, sheep are used as beasts of burden; they are driven unshorn to the place whence the merchandise is to be removed, when the fleeces are exchanged for the corn or other commodities with which they return laden, each animal carrying about 18 lbs. weight.

The carpet maker having supplied himself with the wool best suited to his purpose, has still to be careful that it has been properly cleansed. This is an elaborate process, since there is as much grease and dirt as there is wool when the fleece is taken from the animal. The successful spinning of the wool, and also the dyeing operations, depend on its having been thoroughly freed from this, although it is difficult to ascertain in what these operations actually consist.

In some districts the wool would appear to be simply washed with soaps, after which it is regularly beaten out with an instrument resembling a violoncello bow, to remove all the coarse substances, and leave the soft part of the wool in the required condition. In other districts I am inclined to think the wool is washed or cleansed in what is called its yolk, and I suggest that this is the possible explanation of the comparative freedom which the oldest and most glossy of the antique carpets have from destruction by moth. This, however, may be also due to the more healthy condition of the animals furnishing the fleeces. The other materials principally employed in carpet manufacture are camel's and goat's hair, and also (but very much less frequently) that of the yak and the ibex. The finest of these is the pashm, or hair which grows close to the body of the goat, procured chiefly in the mountains of Afghanistan.

In Southern India silk is occasionally used, a material giving wonderfully lustrous effect to the pile of the carpet, but scarcely so appropriate. This lustre appears to greater advantage when the medium is goat's or camel's hair, and is less liable to injury from wear. An example of the silk manufacture taken from the Vincent Robinson collection, and shown on the walls of the Society's room, is constructed entirely of silk, and made at Warrunghul, probably in the 16th century. As a mere piece of weaving it is marvellous, having 400 stitches to the square inch. Of course, such specimens were never intended for the feet, but only to be sat upon—in the East.

But even in the north of Europe carpets in those days were not put upon the floor. In England the floors were covered with rushes until early in the 17th century. Euphues replies to the Lady Flavia, "Faire ladie, it were unseemlie to strew green rushes for his coming, whose compagnie is not worth a straw."

Early in the 16th century, a carpet, in England, meant a table-cover, as we find in Ben Jonson's plays, and also from Dyce's Notes on Middleton's Works. We are all familiar with the appearance of these table-covers from the old Dutch pictures, one of the most magnificent being the Terburg, in the Royal collection. Those illustrated by the Dutch are all of Turkish manufacture of the 16th century. The designs, geometric in treatment, recalling Turcoman Nomad work—but the colouring that of Smyrna at its very best.

Sir William Browne, writing from Flushing, in 1602, says, "I have bought a Turkey carpet for my lord of Bergeveny, 7 Dutch ells long. It cost 27 pounds sterling, but it is esteemed very fine, and well worth the money" ("Sidney Letters," vol. 2, p. 26).

The modern Smyrna carpets have so degenerated, as even, in England, not to be accounted ornamental; but then, as Mr. Browning says ("The Ring and the Book,") we are content with

> ". . . . . . A mat to save bare feet,
> Since carpets constitute a cruel cost."

England, however, in this matter of cost, presents a curious contrast to the Venetian and other States of North Italy in the 15th and 16th centuries, whose grandeur, like that of England, was based on trade. Sismondi very happily notices this when he says, that trade was then carried on by the nobles with princely magnificence; idleness only was disgraceful, whatever the rank of the person indulging in it.

Returning to our subject, the wool is then spun and subsequently dyed, the latter process being one of the most formidable in connection with the manufacture, upon the successful performance of which, much of the beauty and durability of the carpet depend.

Any extended investigation into dye stuffs, and methods of dyeing, would be out of place here; yet, I cannot altogether pass the subject over, pausing only to consider the three primary colours—red, yellow, and blue. Where the baneful effects of modern innovation and commercial demands have not been felt by the natives, and in those districts where nature has provided the local dyer with materials at hand, his ingenuity has usually been productive of excellent results unassisted from without.

In other districts, where innovations have recently interfered, the natives were formerly dependent only on their local supplies and primitive methods, and this alone is sufficient to account for the variations in tone, and much of the beauty of colour, which I have already shown to result from the varying geographical conditions under which the wool itself was obtained. It would almost appear capable of proof, too, that something of their brilliancy and durability depended on the fresh condition of the raw material when used.

Wool, when exposed to a multiplicity of operations, including boiling, looses much of its cellular fatty matter; this must impair its glossy appearance and its durability.

Red.—Modern carpets are dyed red chiefly with lac or cochineal; but the proper materials, and those from which the old reds were made, are, in the first place, kermes, and in the second, mungeet, or Indian madder (*Rubia cordifolia*). For a short account of kermes I would refer to the remarks in my book, "Eastern Carpets." A cheap substitute for kermes is cochineal (*Coccus cacti*), not strictly a vegetable substance, it being an incrustation formed by an insect on the bark of several species of the *ficus*.

The process for the use of madder, practised by the natives, stated briefly is this:—A decoction is made from the galls of the tamarisk (the *Mai farash* of the natives) to facilitate the absorption of the dye in which the wool is steeped; it is then submitted to the hot solution of madder, which is fixed by the alum mordant.

These are the materials most generally used; but there is little doubt that a great variety of other substances and methods of using them have obtained in districts in which different materials are indigenous; as, for instance, in Mooltan, where the morinda is, or was formerly, used as a red dye.

Yellow.—The pomegranate is another Eastern dyestuff peculiarly valuable, having both astringent and colouring properties, thus serving both as mordant and as dye. It produces, with potash or ammonia, a fine yellow, or with ferruginous salt, a black. All parts of the plant are astringent, but the rind is the part generally used.

This fruit, as we know, is only found in warm climates, the best coming from Balabeag, near Cabool, Candahar, and Jellalabad. It grows also in Afghanistan and Beloochistan at elevations of about 6,000 feet, and on the east of the Suleiman range at about 4,000 feet. All these places, as well as Mazanderan, Bokhara, and Asia Minor—all countries, indeed, where the pomegranate is indigenous—singular enough, correspond to the districts where the finest wool is grown, and whence, as a consequence, come the most magnificent carpets in the world.

Blue.—The use of indigo is generally known. Any particular reference to the methods of its employment by Orientals would be unnecessary for our present purpose. The plant is indigenous in India, and the dye has been used from time immemorial, in proof of which we have actual specimens of mummy cloths found at Thebes, which have been subjected to chemical tests. At a much later date it was only known to the Greeks and Romans as a pigment, and it was not until after the middle of the 16th century that it came into use in Europe.

It may be of interest to notice that there were no dyers in England until 1472, when Edward III. incorporated a society of them in London, bringing them from Flanders.

The chemical changes indigo passes through on exposure to the sun's rays afford, as it appears to me, a lesson which we should do well to consider seriously, namely, that there is no possible substitute for the sun as an agent in the process of dyeing. Science has performed wonders, but at present she has failed to produce artificially, in the laboratory or the dye house, that which nature has provided gratuitously for the artificer in a hot climate under the fierce rays of a tropical sun.

Tracing, then, the acknowledged superiority of oriental carpets to their cause, may we not conclude that geographical and climatic conditions exist which account for their unrivalled perfection, and which it is beyond the power of man in northern latitudes, backed by all his science, to imitate?

The mere manipulation in the manufacture of carpets is the same all over the East, and need not be minutely described here, consisting as it does in knotting with a double twist the wool forming the pile of the carpet firmly upon the foundation. This latter is made with the finest sorts of wool, cotton, or silk set up on horizontal beams, forming the loom, and being the nearest approach to machinery the most magnificent carpet ever needs. The artificer sits on, or a little above, the ground, with his legs in a hole fronting his work, which is wound on to the bottom roller as it is completed, the pile being cut to the required length for the finished surface of the carpet.

In the coarser kinds of Indian carpets a workman can do about 5 or 6 inches, of about 18 inches wide, in a day, at a cost of about 3 annas. For the finer kinds longer time is required. Coarse rugs are generally made of cotton for the Hindoos, and of wool for the Mahommedans. The latter, especially in Persia and Arabia, frequently use silk and even gold thread for the carpets intended for shrines, and formerly even precious stones were added. In a country like India, where the classes of society may be divided abruptly into the extremely rich and the very poor, we should expect necessarily to find only two kinds of manufacture, a great number of coarse fabrics and a few of exquisite fineness. For the production of the latter the people of India seem formed by nature. In the Hindoo, with his supple form, pliant fingers, and exquisite sense of colour, aided by his indefatigable perseverance, we perceive the Heaven-born weaver. Where in Europe, with all our mechanical appliances, can we rival the muslins of Dacca? And yet they are produced without machinery, without capital, and without the organisation so much relied upon by Europeans. The weaver is a solitary individual, working a loom consisting of a few bits of wood roughly put together, with no expedient for rolling up the warp, and often compelled to ply his work in the open air in all vicissitudes of weather, since his hut is of insufficient capacity to contain it.

If, again, we consider the artistic power of these peoples, we are still more impressed with their seemingly unconscious and special gifts. It may be called an instinct, for even in those races, devoid of mental and social cultivation, we find, not the germs only, but the full growth of a faculty for harmonious colour and design, and this in a degree to which Western nations more elevated in the social scale can make no pretension. This subject of design is one of the most interesting features in Oriental work, its origin and development one of the most difficult to pursue.

Much of the success of the Orientals seems to be in their abhorence of novelty; indeed, I should like to make it an axiom that in fine design novelty must be excluded. How far this may accord with the practice of the Orientals may be judged, when we reflect that the greater number of the designs in use to-day not improbably met the gaze of hundreds of generations before the time of Abraham.

Thus the pattern which has had the widest reception in modern times for carpets is the one commonly known as "Heratee," a name given it recently without any justification, unless, indeed, for the reason that it was never made there. There is now no tracing the origin of this charming design from which thousands of carpets have been made, with no two alike. The theme remains, but the colouring, and even the scale of drawing, is ever changing with marvellous ingenuity. I can stop to consider only one more pattern of Indian origin, as the other was of Persian. This pattern seems to have been suggested by orchid growth, the blossom of the dendrobium being a very conspicuous and beautiful feature. It could only have been devised by a people with art instincts both passionate and fanciful, who wove into their designs the magic hues of poetry and fiction; whose touch, so far from vulgarising by attempts at novelty, antiquates and ennobles.

The grandeur of the Oriental treatment of design may be illustrated in a vivid manner by reference to the carpet formerly filling the Hall of Forty Columns at Ispahan, some fragments of which still remain there. It was originally 135 feet long by about 65 feet broad, of extremely fine quality, with pattern enlarged and coloured on a gigantic scale, and a colossal border befitting the space in which it was spread. Afghan artificers alone could have fabricated such a gorgeous and palatial thing with an equal refinement of detail. Where could a fitting place be found for such a work but in the palace of an Italian noble of the Middle Ages, whose rooms were marble halls, and whose chairs were thrones of state?

Where in England, then or now, are we likely to find places sufficiently spacious for similar triumphs? The contemplation of such designs, as it were, emancipates us from the matters of fact of daily life; we are carried away by a kind of admiration, bidding us wander beyond the radius of our prejudices, yet restraining us within the limits of tradition. This tradition, too, is a part of the inheritance of the human race, and to abandon it in favour of novelty is to forfeit one of our highest privileges.

It is impossible to exaggerate the influence of the Saracens on the textiles of Southern Europe, especially those of Spain and of Sicily, and it is curious that this has not at present received the attention it seems to deserve. Among their many characteristics, no proper distinction seems hitherto to have been made, and they are all classed together under the generic name of Persian. Even the French, who have been the only serious collectors of textile treasures in this century, do not discriminate. Yet many of the most wonderful carpets, as well as of other stuffs, are most unquestionably Saracenic. I am aware that at present I am unsupported in this opinion, but careful comparison will, I think, in time establish it as the correct one, and that in fact those carpets hitherto known as Persian, but found in Spain and Southern Italy, were indeed made there by Saracenic artificers.

The only alternative to this theory is, as the work indicates, that Baghdad and the valley of the Euphrates was the source, but at the date of their manufacture production must have ceased there. I confess to great reluctance in admitting such an antiquity as the latter half of the 15th century for some of these specimens, but increased opportunities of comparison have gone far to remove this objection. The Saracenic element is, indeed, so evident, that I can only feel astonished its existence should not have been recognised by other investigators.

What an influence is there in a name! That of Persia having become a kind of shibboleth, by which all kinds of wonders might be worked among dealers, it may have been thought dangerous to disturb or risk its supremacy, and thus weaken the devotion of a public too preoccupied to reconsider the reasons for its faith.

The Saracens were driven out of Spain about 1490, but many of their number remained, and we have every reason for assuming that Saracenic artificers worked in Spain for a century later. That Spain was originally provided with carpets direct from Persia is abundantly evident; of this, one instance will suffice. Abdoul Rahman, the third ruler of Cardova, in the 10th century, was presented by Abu Melik on his appointment as Grand Vizier, with a variety of costly and most magnificent treasure, among which are particularised thirty Persian carpets, as being brought and laid at the foot of his throne. Oriental influence came also to Portugal, but from further east, about the time of the expulsion of the Saracens from Spain. When Vasco da Gama began that celebrated voyage of his in which—

> "For many a day and many a dreadful night,
> Incessant labouring round the stormy Cape,"

he brought from the western coast of India wonders of the arts, adding fresh sources of inspiration scarcely less powerful than those which already abounded in that favoured peninsula.

It is a remarkable circumstance that, with all the wealth of Europe, there is probably no Royal collection save only that of the Sultan of Turkey which possesses really good specimens of choice Oriental carpets. Very much the same may be said of all the museums of Europe, for with the exception of a German fragment, I know of none that are in themselves of any importance, or which would compare with examples in the hands of private collectors. In the public interest it is a subject too for much regret that there is now hardly any possibility of supplying this defect, since all the choicest existing examples known have been absorbed. The last places to look for fine carpets now are probably those which originally produced them. Most, if not all, of the splendid examples have been sent away.

Where are now the grand Durbar carpets of India? In England one only of these is to be seen (as far as I am aware) in what is now known as the Vincent Robinson collection. In France several private collectors have each two or three very important specimens, but no person in England could be found to pay the prices which the French owners have given for them. Of one carpet alone it may be said, that were it known to be for sale, every connoisseur in Europe would be attracted, and thus draw a greater crowd of pilgrims than the one that annually accompanies the holy carpet itself to the Kaaba. Such specimens as these ought to be in some national collection, for the formation of public taste.

Yet, I am unpatriotic enough to say that I should be sorry to see them in any English museum, when I remember that, only a few years ago, it was deliberately proposed, and, I believe, partly executed, to cut all the East India Company's collection into small fragments, for the purpose of distributing them among the museums, as if they were so many bits of cotton shirting or calico. What should we say if the pictures in the National collection were to be similarly served, on the plea that fresh producers could judge of the materials and skill employed in the original by examining a fragment of it?

This comparison is not so far-fetched as it may at first appear, since an art carpet must be seen as a whole for a judgment to be formed of the distribution of its pattern and the relation of its parts, the latter being seldom repetitive.

But, indeed, we have no collection in England of any value to the nation from an art point of view. It is difficult to understand with what motive the carpets now at South Kensington Museum were collected. If to show specimens of the *chef d'œuvres* of a past work, it is failure, as there are not half a dozen examples of fine work in the museum. If it was designed to show off and advocate the jail productions of India, for whose advantage was it intended? Certainly not for the art student, nor for the carpet designer, nor for the public, because all three classes go there for instruction, and to see what to covet and imitate, not what to avoid.

But the whole action of the Government of India, in reference to the carpet industry of the country, as was demonstrated by Sir George Birdwood, has been characterised by a sort of blind infatuation. It may be briefly sketched thus:—Twenty years ago—the reputation of India for its carpets having been established in Europe at the first Exhibition of 1851, and subsequently well developed by private enterprise—the Government of India, casting about in the midst of difficulties with taxation, blundered on the scene in the following manner:—

In all the jails in India, several thousand prisoners were being maintained as a burden on the revenues of the country during their term of servitude, and it occurred to some one in authority that if any kind of work could be taught them, their imprisonment might be made a source of profit instead of loss. In an evil hour they hit upon the carpet industry as one which was flourishing, with a new life imparted to it, and a wide field for expansion.

Now this new life, had it been allowed to develop itself naturally, would have continued to increase in the old methods with the results which had obtained its reputation, and with ever-increasing prosperity. The native weavers, whose numbers would have multiplied whilst the demand for their work increased, would have benefited first, and the general trade of the country still augmented in a legitimate manner.

I have already shown that the reputation of these carpets was not a fresh creation; it was an art upon the practice of which thousands of our fellow-subjects in India depended for their livelihood. It had its traditions, its methods, its caste. We know that these people have held their pre-eminence in the art of flat surface decoration during all historic time. The most cultivated peoples among the ancients admired and acknowledged it. In mediæval times it was equally sought after, and the only kindred arts which claimed any considerable merit whatever were those founded upon it. No rival had at any time supplanted it. The Government, backed by the credit of this great nation, set itself to trade on the reputation which had been thus obtained, and deliberately, by the introduction of cheaper methods, and what was practically slave trade, to undersell the art weaver. Buildings were adapted, plant on so-called improved English or European models obtained and fixed, and the armaments of chemical laboratories with their processes introduced; and such a system of organised work set up as completely transformed not only the trade but actually the carpets themselves which were the foundation of it. Instead of the individuality of the designs, the subtle tones of many shaded colours, the curious testimony which each carpet bore to its own history, in which each individual weaver left some marks, unconsciously often, of the beginning or the ending of his day's work, the record of the finish of one pot of dye and the beginning of another; the lassitude which came over the weaver when he became a little weary, and enlarged the scale of his work; the slight transition of colouring perhaps which often characterises the two ends of a very large carpet. All these subtle changes, which were so charming in the old carpets, the jail authorities set to work energetically to disregard, and ultimately, by elaborate organisation, to drive clean out of the business. By degrees the poorer weavers disappeared altogether from the scene. It must be borne in mind that formerly, under the old system, these people harvested their crops in their proper season, so that there were many and vexatious intervals of cessation and delays, no doubt, for the expectant purchaser who had advanced his money in the olden time, and whose patience was often somewhat taxed before he got his carpet. But then who would expect a picture, for which a commission had been given to a painter, to be delivered at his house the moment it was wanted, like a door-mat or a ton of coals? When at length the carpet did arrive, what a lovely object, what fresh delights awaited the happy possessor, as, during months afterwards, the little irregularities of its early existence were discovered one by one, like strange surprises? The jails, however, worked on, and the authorities, with their cheaper methods and increased profits, were encouraged to extend the operations to a great number of the principal jails throughout the country, regardless of the artistic character of the work they produced; laboriously matching colours, and counting stitches, and blind to any other necessity than the durability of their work, even in this not being uniformly successful. The great aim of the jail authorities was to imitate the outline of the detail in each pattern, to match the colours as the assistant in a draper's shop would do, but, above all, to guarantee the durability of the article they produced. The whole concern had degenerated into a mere money-making, trumpery machine-shop trading affair, worked on money borrowed from the nation. The whole character of the work was changed. The gentlemen in charge of the jails found themselves in a most novel position. They were military or medical gentlemen, or of some other profession, but suddenly they had become manufacturers. With no training or special talent for such occupation, they had to plunge into unknown mysteries. No doubt they were perfectly sincere in the belief that the task was not beyond their powers, which, had it consisted simply in discriminating between a good and durable carpet and a bad one, and reproducing it, would have been perfectly true. All the varied art and poetry of the ideal was for them as nothing. For them, those carpets which have for the artist dreamy imaginings did not exist. Such carpets are in fact, poems in wool; they are transcendental, and are beyond the comprehension of realistic men, to whom a carpet, however lovely, is a carpet and nothing more.

But in these days of machinery and steam we live at a rate beyond all precedent. When, therefore, all the new processes intruded on the Indian weaver have become fixed and settled, and the traditional processes which have survived so many centuries have fallen into disuse and oblivion, who on earth is to revive them?

Observe the result in this case. Men were employed to superintend the prisoners, and the latest improvements from Europe were introduced by degrees, and, as a consequence, an enormous output of carpets, which are no better, if they are no worse, than English ones, made in the same way by hand.

Government officers are naturally not concerned about the overthrow of a handicraft which they do not understand. But observe the grave consequences. The loss of the reputation of Indian carpets as art fabrics, which was their claim to public admiration, has already set in, in those quarters where it was originally created, viz., among artists and leaders of taste, who, be it remarked, the public invariably follow in the long run.

In matters of taste there is no disputing. Now, it is quite possible to demonstrate that an artist or a manufacturer is incapable of commanding an army in the field, or to cure malignant disease, but it is quite another matter to prove the incapacity of a military or medical man to design or manufacture a carpet or any other textile. Yet the one is as inconsistent as the other. Each of these pursuits requires the devotion of a life, and in the proportion as the individual is qualified for the one, in that degree he is disqualified for the other usually.

As an instance of the infatuation of the English authorities in their treatment of the native arts, I will give one or two short quotations from a recent pamphlet printed in Bombay, being, in fact, a report on dye-stuffs to our Government at home, made by a local officer. He says—

> "They (the natives) can give beautiful and permanent colours . . . . . . but the methods of dyeing practised in India are generally tedious and complicated, and there is no doubt that if Western skill and Western science be applied to the products, a great improvement will be readily effected."

A great "improvement!" In what way does this gentleman suppose that we can improve them? He goes on to say that—

> "Although chemical science is not understood by the natives, the richness of the natural products, the results of happy accidents and elaborate painstaking experiments in their employment, have been fruitful of good results."

Is the official mind incapable of connecting cause and effect? May we not refer these "good results" to those "elaborate painstaking experiments" with the "happy accidents" we know invariably to follow, and from which, I believe, they can only be obtained? The chemistry of Nature works for the native, however tediously; and I know of no instance in which Western science has interfered in art work without disaster.

It has all along been assumed that the manufacture of these carpets, which has incidentally been the ruin of the caste weaver, as a matter of course, has been one of great profit to the Government, and consequent saving of taxes to the country. I should, however, like to raise one or two questions on this point, leaving altogether aside the State policy or morality of the matter. Have the accounts been so kept as to show the whole expenditure involved in the undertaking, in the same way as an ordinary manufacturer, trading with his own or borrowed capital, would have to do?

Manufacturers and even Indian carpet weavers have their creditors to answer to, if their accounts do not include every item and balance themselves. They have, therefore, to allow for such charges as these, under the head of capital account:—Building account; first cost of plant, &c.; first cost of materials; what charges have been made on account of labour of the prisoners or of their maintenance and superintendence; maintenance and repair of machinery and buildings; simple interest on monies advanced by the Government.

Now, it is evident that these jails have always been a kind of charge in account with the taxes of the country. If, therefore, the trade has been profitable, clearly the taxes of the country should have been relieved, since the profits arising from the trading ought to be in excess of any charge in connection with the manufacture. But unless labour and rent charges have been added in account, the weavers have been undersold with no corresponding advantage to the taxes. Even then it partakes of the nature of a monoply, and, as such, carries us back to one of the forms of corruption which it has been our pride to suppose completely a thing of the past, never more to be revived.

If I am correct, some of the above charges have not been provided for in the way which a manufacturer, without the resources of the Government at his back, could have made profitable, and although I do not for a moment imply that there has been, or possibly could have been, any misappropriation of money, I should like most distinctly to say that, unless the accounts of these jails are charged with every item of expense, including labour, the prime cost of their productions cannot have been fairly represented, and their profits merely illusory, involving either on the one hand the underselling of the native weavers, with a seeming profit and a real loss, or on the other a monopoly, supported practically by slave labour.

DISCUSSION.

Mr. HUNTER DONALDSON said the paper contained a large amount of very valuable information, and also showed, what he already knew, that Mr. Robinson was an enthusiast who believed that true art could only be found in connection with Oriental design. He ventured to question that view, for though he admired Oriental work, he also believed it was possible to have very beautiful carpets designed on an altogether different basis. It seemed to be suggested that Eastern productions were alone entitled to be called art carpets. The word "art" was one which he thought people were getting rather sick of; it had been applied to almost every production, but certainly if it was not possible to have an art carpet which was not Oriental, it would be a great pity, for there must be many people who could not afford to indulge in such expensive luxuries. With reference to what had been implied rather than expressed, he would suggest that there were other forms of art which were quite as true as that which was illustrated on the walls. Mr. Robinson had had a long acquaintance with them, and had come to love them; as with vice, which it had been said you first endure, then pity, and then embrace, Mr. Robinson had come to that frame of mind in which he could embrace even what he (Mr. Donaldson) should call vicious in Oriental carpets. In some of these specimens there were exceedingly beautiful forms, lovely colour, and delightful suggestiveness, and what had been said of the beautiful carpet of undoubtedly Saracenic origin would tend to support his view, but he could not agree in his unreserved admiration for all Oriental work. There were good and bad amongst them, and the one at the back of the Chairman certainly seemed to him utterly bad. It suggested a form of disease, and was certainly not a thing he could expend his love upon. A broad general principle might be laid down, that the flat treatment would commend itself to all persons of cultivated taste, but there was a kind of carpet in which there was not that flat treatment, and yet it was very admirable. He referred to the Aubusson carpets, in which there were generally flowers at the outside and in the middle, which was usually covered by a piece of furniture; but between the centre and the border, which no one trod upon, there was flat treatment, and if beautiful form, combined with harmonious colouring, were acceptable to the cultivated taste, then an Aubusson carpet was just as beautiful in its way as the Oriental, and in just as true taste. He knew Mr. Robinson held very strongly that there was no truth outside the Oriental, but in that he ventured to think he was altogether wrong. There were examples of French carpets, and also English—but especially French—which were equally beautiful, and therefore, while he agreed that these carpets had at all events the merit of being the original carpet, and suggested to all manufacturers combinations of colour and form which were on the whole extremely acceptable, still there were amongst them good, bad, and indifferent, and whilst some were exceedingly beautiful, others were equally detestable.

Mr. PURDON CLARKE said he had the charge of the large number of carpets which had been mentioned to-night as being examples of what should not be either owned or copied. Of course, when he looked at the specimens exhibited he could not but wish that the nation possessed more like them, but he believed they had one which Mr. Robinson had probably forgotten, though it was a leading carpet in his collection some years ago. The silk carpet had puzzled a great many people; whether it was of Turkish origin or Persian was not known, and probably never would be; all that was known about it was that several of the same pattern came, from time to time, from Armenia. All that was known of the Saracenic carpet was that it was neither Indian, Persian, nor Turkish; perhaps a hundred examples of them were known altogether; one or two only in Persia, where they were considered strangers, a dozen or so in palaces in India, and in two of the shrines, and the remainder in Spain, in Toledo, Saragossa, and Seville, and in all these places they were spoken of as strangers. They could be traced back about 300 years, but beyond that nothing was known of them. The carpet in the centre probably came from Central Asia about the same time, but it was covered with Tartar designs, and in fact it was very much Chinese in design. There was a fragment in the corner of the room which certainly came from Central Asia; there were many MSS. existing showing the same treatment of figures and peculiar costumes, and it was probably the oldest piece in the room, possibly 500 years old, but the central portion was unconnected with the others—in fact it was a lot of pieces sewn together.

Mr. JOHN SPARKES said that during the reading of the paper, a feeling of regret which he had often felt, was intensified that some means were not taken to obtain authentic copies, by photography or otherwise, of these historical carpets, of which very few existed in Europe. It seemed to him that public money would be very well spent on such an object. Mr. Donaldson had severely criticised the carpet in the centre, but in all probability it was seen under a disadvantage in that position as a wall decoration. No doubt it was meant to lie flat, not to be trodden upon, but in all probability to be sat upon. He could conceive of number of Oriental diplomatists, when engaged in council, and endeavouring to get the better of their antagonists, being very much engaged in studying the miniature figures represented. Under such conditions the carpet would have a very different effect, and the wonderfully fine work in it would be more appreciated. The impression on his mind, as an outsider, was that the wealth of design as well as the colour was what made the beauty of these Eastern carpets. There was no absolute repetition, as there could be none when each row of stitches was made from a prescription made at the time. There was no mechanical repetition, and therefore the carpets were more likely to commend themselves to artistic perceptions than to the average public. It was a good thing that many did not exist, for they were precious things, which would be appreciated only by a few who were able to see the poetry in wool which they really were.

Mr. L. FOREMAN DAY said he had designed two or three carpets, but it was a very hopeless kind of business. There were in most styles good, bad, and indifferent; but the English carpet was a monstrosity as compared with the Oriental. The very carpet which Mr. Sparkes said should be sat upon, and which Mr. Donaldson had sat upon, did not seem to him so hideous—in fact, he had been admiring it the whole evening. He did not see any disease it it, but if there were, and designers were inoculated with it, it would be all to the benefit of English art. One reason why English carpets could not possibly be equal to Oriental was that they were manufactured, and a carpet manufactured was a carpet spoiled, and a design spoiled. The English manufacturer appeared to think that the more even and hard he could make a thing, the better it was; the Oriental was content with the inequalities which came of working with his hands, and with the delight which came of making beautiful things. It was not possible to produce beautiful work by machinery as it was by hand labour. He did not know what the machine would do if you gave it a chance, but at present the only endeavour was to produce cheapness, which was a very different thing from economy, and altogether abominable. If the British manufacturer would devote his time, energy, and capital to seeing what the machine could do in the way of beauty, there would perhaps be a chance.

Mr. MARTIN WOOD remarked that Mr. Robinson, in his paper, had utterly smashed the jail system of manufacturing carpets, but he had listened in vain for any suggestion as to how the native industry was to be restored. He referred to the great impetus given to the manufacture by the Exhibition of 1851, which had not been allowed to develop itself naturally, and he would ask why did not the trade then develop itself, when there was a demand in the West. He could only suggest that it was because the weavers were too poor, that they could not increase their numbers sufficiently rapidly, as was the case with other handicrafts in different parts of India. Mr. Robinson had not gone into the abstruse question of the origin of these designs, and had not even stated where the different specimens which were exhibited came from, which would have been very interesting, as they were very diverse in character. He should like to ask the Chairman if the *put* which had been referred to was really wool; he had understood that it was down, and that it grew on many other animals besides sheep. If Mr. Robinson were an enthusiast, he was certainly justified in his enthusiasm, but the question was, how could that enthusiasm be applied so as to revive this indigenous art in India.

Sir PHILIP CUNLIFFE-OWEN, K.C.M.G., said after the diverse views which had been expressed by Mr. Donaldson and others, he could hardly be expected to say anything about the relative merits of Oriental and other carpets, but he had much pleasure in moving a vote of thanks to Mr. Robinson, which he might say was due to him, not only from that meeting, but from the whole English people. On the part of those who had had to do with the various exhibitions, he tendered him their warmest thanks for his hearty, generous, and liberal co-operation, and in fact he did not know what they would have done without him. He took a most important part in connection with the Paris Exhibition of 1878, where he had quite a triumphal section in the Indian court, and did honour not only to England and to Oriental carpets, but to the Exhibition itself. To him was due that great development which had taken place in the public taste in this direction since that date, and he had been informed by the Bon Marché in Paris that since 1878 the conductors of that establishment had spent more than half a million sterling in Oriental carpets. The book which Mr. Robinson had published on the subject was well worthy of him. It took him years of labour; it was beautifully illustrated from drawings by Mr. Robinson's sister, and chromo-lithographed by Mr. Griggs, and was a perfect epitome of Mr. Robinson's love for these carpets. They owed very much to him at South Kensington. When the India Museum was transferred from the India-office to South Kensington they had the privilege of having the magnificent collection of Mr. Robinson's best carpets, and for some years a special court was entirely devoted to them.

The CHAIRMAN, in putting the motion to the meeting, said he would confine his remarks to one practical point, which was his conviction that they had seen the last of the good old style of Indian carpets. The splendid display of Indian carpets made at the Great Exhibition of 1851 first awakened his friend Mr. Vincent Robinson's enthusiasm in them; and the Indian Government had contributed very largely in carpets to the various International Exhibitions held since then, and more largely, perhaps, to the forthcoming Exhibition than to any of the previous ones. But he was sorry to say that of all that were sent there was not one, so far as they had yet been unpacked, that was not absolutely vile in colouring. It was perfectly awful to note the degeneration that had taken place in the artistic qualities of Indian carpets in recent years. At one time he attributed this degeneration almost exclusively to the influence of the Government Schools of Art and the jails; but at present he felt that it was chiefly due to the influence of English commerce on the historical handicrafts of India, and that the Schools of Art were really doing all they could to stem the tide of deterioration due to it. At least this was true of the School of Art at Bombay, under Mr. Griffiths; and at Lahore, under Mr. Kipling; and Madras, under Mr. Havell. At one time you might go into the bazaar at Baroda or at Bombay, and select any textile fabric blindfold, and it was sure to prove enchanting; but now it was almost impossible to find any of these stuffs in Western India which were not tainted with the aniline dyes. This had gone so far that even the most sacred articles used in the worship of the gods were contaminated with them. There was a sort of glove worn when telling the beads on a rosary before the gods, and all the samples of it sent to the forthcoming Exhibition from the Bombay Presidency, were ruined artistically by the thread used in embroidering them being coloured with aniline dyes It was a most remarkable fact, for the use of these dyes on such articles amounted to a ceremonial pollution of them. Nearly all the textile fabrics sent from Bombay were smitten with the same prismatic leprosy—he could call it nothing else. As for the origin of patterns, it was an abstruse question, hard to solve without tiresome qualifications. The correlation of patterns could only be sought in religious symbolism, and it was only through the conquests of the Turks and Mongols having placed a barrier between the East and the West for nearly 300 years, that the absolute unity of the industrial arts of Europe and Asia had been lost sight of in the West, and that we went so far astray in all our speculations as to the origin of conventional decorative forms. With regard to Mr. Martin Wood's question, he was not aware of any difference in the structure of the under-wool used for the finer Cashmere carpets and shawls to distinguish it specifically from wool.

The vote of thanks having been carried unanimously,

Mr. VINCENT ROBINSON, in reply, said he felt quite overwhelmed, first, by Mr. Donaldson's criticism; and secondly, by the extremely eulogistic terms in which Sir Philip Cunliffe-Owen had spoken. He would endeavour, however, if possible, to throw off Mr. Donaldson's nightmare. Mr. Donaldson admitted that the flat treatment was the correct one, and then he went on to say he admired the Aubusson carpets, and that they might at any rate stand on an equal footing with the Oriental ones. Enlarging upon them, he said that the border was a thing upon which the people never trod; and if people went about a room lowering their eyes and raising their feet as they passed the border, they might avoid such a catastrophe, but he was more absent minded, he did not always want to see exactly where he was stepping, and, therefore, he preferred the Oriental patterns. Mr. Clarke said the large carpet was from Central Asia, but he did not think that opinion would bear investigation. The pattern had no doubt Tartar features in it, but at the time of Tamerlane there was a great admixture of patterns, and though he had no proof of it, he believed the carpet was made in Baghdad, or somewhere in the Euphrates valley.

Sir PHILIP CUNLIFFE-OWEN said he hoped the members would reserve their judgment on the Indian carpets in the Exhibition until they had seen them, as he thought the Chairman had given too gloomy a description of them.

The paper was illustrated by a collection of Oriental art carpets, exhibited by Mr. Vincent Robinson, which were hung on the walls of the meeting room.

APPLIED CHEMISTRY & PHYSICS SECTION.

Thursday, March 11th, 1886; Capt. W. DE W. ABNEY, F.R.S., in the chair.

The paper read was on "Films and Paper as Substitutes for Glass in Photography." By LEON WARNERKE.

The report of the meeting will be given in next week's number of the *Journal.*

UNIFORM MUSICAL PITCH.

The following Circular and Memorandum are in course of issue to Professors of Music at all Colleges and Universities, Principals of all Public and Private Colleges, Academies, Institutions and Schools for the Promotion of Music, Private Teachers of Singing, Conductors of Choirs and Bands, Public Singers and Instrumentalists, Professional and Amateur Musicians, and others interested in Music:—

CIRCULAR.

March, 1886.

SIR (OR MADAM),—I am instructed by the Council of the Society of Arts to send you the enclosed Memorandum on Uniform Musical Pitch, and to ask you to have the kindness, in the interests of Music, to reply, in the manner stated, to the three questions given below, which are based upon the facts stated in the Memorandum.

Your obedient Servant,
H. TRUEMAN WOOD,
Secretary.

QUESTIONS.

Questions 1 and 2 should be answered by Yes or No only, without any addition, question 3 by the number of double vibrations in a second for either A or C (*not* for both notes, to prevent error), also without any additions. The Council of the Society of Arts will, however, be greatly pleased to receive further remarks, on separate pieces of paper, written on one side only, and duly signed.

⁂ It is particularly requested that the answers may be sent to the Secretary of the Society of Arts, Adelphi, London, W.C., not later than 30th April, 1886.

Questions.

1. Do you consider it advisable that a Uniform Musical Pitch should prevail in England?
2. If you answer Question 1 in the affirmative, are you willing to accept the French Pitch A 435, giving equally tempered C $517\frac{1}{3}$, in England, in order that the Uniform English Pitch may be the same as the officially Uniform International Continental Pitch?
3. If you answer Question 2 in the negative, and Question 1 in the affirmative, what is the Uniform Pitch that you would prefer for use in England?

Name..................................

Professsion..............................

Address..................................

Date.....................................

⁂ The signer is requested to state if he or she is a Professor of Music or Physics, adding at what University or College, a Mus.D. or Mus.B., the Principal of any College, Academy, School, or other Institution for Music, a Teacher of Singing, a Professional Singer (adding the kind of voice), a Band Conductor, a Choir Conductor, an Instrumentalist (adding the name of the instrument), an Amateur, &c.

It is requested that names may be given, as it is desired they should appear in the list (should one be published). Ladies are, therefore, requested to prefix Mme., Mlle, Mrs., or Miss, to their names, to prevent mistakes, and gentlemen to give any title or any initials they may wish added to their names.

MEMORANDUM.

1. On 1st July, 1860, a Standard Pitch Note called the *Diapason Normal*, and consisting of A making 870 single or 435 double vibrations in a second, giving C $517\frac{1}{3}$ in equal temperament, was established for France by Imperial Decree, founded on the recommendation of a Government Commission, signed by the following members:—Messrs. Pelletier (on the part of the Government), Despretz and Lissajous (physicists), General Mellinet (on the part of the bands of the army), Camille Doucet and Ed. Monnais (for the theatrical and operatic department and conservatory of music), and Halévy, Auber, Berlioz, Meyerbeer, Rossini, and Ambroise Thomas (six well known composers). This pitch has remained in use ever since.

At that time the pitch of the French opera was A 448, giving equally tempered C $532\frac{4}{5}$, exactly a quarter of a Tone higher than the pitch proposed, but only one member (understood to be M. Berlioz) proposed that the fall should not exceed an eight of a Tone, which would have given A $441\frac{3}{8}$, and equally tempered C $525\frac{1}{10}$. The pitch adopted was exactly a quarter of a Tone sharper than Handel's.

2. On 19th March, 1879, Spain adopted the French Standard Pitch.

3. On 19th March, 1885, Belgium adopted the same Pitch by Royal Decree.

4. On 20th June, 1885, a public meeting held in St. James's Hall, convened and presided over by the Principal of the Royal Academy of Music, voted that "in order to annul the great inconvenience consequent on the discrepancy of Pitch in this and other countries, it is desirable to adopt the French Normal Diapason" or Pitch Note.

At this time, English wind instruments are usually made to the pitch A 452, C $537\frac{1}{2}$, exactly one-third of a Tone sharper than the French Pitch; and seven-twelfths of a Tone (that is rather more than a semitone) sharper than the pitch used by Handel, Mozart, Beethoven, Rossini, and Weber.

5. On 16th, 17th, 18th, and 19th November, 1885, an International Conference on Musical Pitch, called by the Austrian Government at the instance of the principal musical societies of Vienna, and of the Directors of the Court Band and Court Opera, assembled at Vienna, and was attended by Delegates (being mostly Conductors of Bands, Directors of Concerts and Operas, Composers and Physicists) from the Governments of Austria, Hungary, Italy, Prussia, Russia, Saxony, Sweden, and Wurtemburg. This Conference *unanimously* adopted French Pitch, which thus became the International Pitch of the Continent of Europe.

At this time the pitch of the Opera at Vienna is, in the report, stated to have been A 450, giving C $535\frac{1}{10}$. Ed. Strauss's band, from Vienna, at the Inventions Exhibition in 1885, used A 452, that is, one-third of a Tone higher than the pitch adopted. Not a single voice was raised in favour of a high pitch at the Conference; on the contrary, high pitch was spoken of only to be condemned. The Pomeranian Regimental Brass Band at the Inventions Exhibition played exactly a semitone higher than French Pitch, which appears from the recent discussions in Vienna to be a practice among some German military bands, and would enable them to play in French Pitch, when necessary, by transposition.

All the principal Governments of continental Europe have, therefore, *officially* adopted French Pitch, although some time must elapse before it can be thoroughly brought into action for all military and civil bands by the assenting Governments.

6. On 12th Feb., 1886, the Society of Arts, which on 3rd June, 1859, had recommended a Pitch Note C 528, giving equally tempered A 444, and was the only public body in England by which a different musical pitch had been advanced, published a notice that they declared in favour of the French Standard Pitch Note A 435, giving equally tempered C $517\frac{1}{3}$.

7. English colleges, academies, operas, concerts, private musicians, instrument makers, and others, are in the habit of using a great variety of different pitches, varying from A 435, giving equally tempered C $517\frac{1}{3}$ to A $455\frac{1}{10}$, giving equally tempered C $541\frac{1}{5}$. The last pitch was used at the Wagner Festival at the Albert Hall in 1877, to the great annoyance of that composer, and inconvenience of his singers, as he himself stated.

In view of this difference of practice, the Society of Arts is desirous of ascertaining the opinions of as large a number of theoretical and practical musicians as possible, with regard to the desirability of reducing the various pitches to uniformity, either on the French basis or on any other.

March, 1886.

Miscellaneous.

COLONIAL AND INDIAN EXHIBITION.

The Royal Commission has recently issued a prospectus of the Exhibition, of which no less than 44 pages are occupied by lists of influential Commissions appointed by the Colonial Governments, and of committees in India. These lists alone show how wide-spread is the interest displayed in the Exhibition, and what important steps have been taken to ensure a successful representation of the participating colonies.

INDIAN EMPIRE.

It may be as well here to say a few words with regard to the means which have been employed in forming the collections in the Indian Courts.

At the request of the Secretary of State for India in Council, and with the sanction of H.R.H. the Prince of Wales, Executive President of the Royal Commission, all the arrangements for the Indian Section of the Exhibition have been entrusted to the Secretary to the Royal Commission, Sir Philip Cunliffe-Owen. The Commissioner for India is Mr. E. C. Buck, B.C.S., Secretary to the Government of India in the Revenue and Agricultural Department.

The official collections have been made under the general administration and direction of the Revenue and Agricultural Department of the Government. The economic products have been collected by

Dr. George Watt, of the Bengal Educational Department; Mr. B. Ribbentrop, Officiating Inspector-General of Forests to the Government of India; and Babu Trailokya Nath Mukharji, of the Revenue and Agricultural Department of the Government of India; assisted by the Exhibition Committees appointed by the Bengal and Bombay Governments and the Chambers of Commerce at Calcutta, Bombay and Rangoon.

The art ware and fabrics have been brought together by committees and special officers appointed by the Governments of the various provinces, or the rulers of native States.

The Indian Section of the Exhibition may be divided into five parts. In the Central Court will be found the art ware and fabrics; in the South Court will be the Imperial economic collections; in the North the private exhibits and the tea and coffee industries; in the Arcade the geographical and military collections of the Government Departments; while in the Palace and its forecourt all the art wealth of India will be displayed in a practical manner.

The Central Court has been subdivided amongst the provinces and states. Commencing at the east end, the following is the order:—Rajputana, containing the Jeypore, Kotah, Karanli, Ajmere, Jodphore, Bikanir and Ulwur sections; Central India; Bombay and Baroda; Bengal, with Nepal; North-West Provinces and Oudh; the Punjab; Kashmir; the Central Provinces; Assam; Burma; Madras; and lastly, at the Queen's-gate end, Mysore, Coorg, and Hyderabad. Each court will have its distinctive screen; and thus will be presented a series of screens, with carving in wood or stone, in inlaid work or in plaster, representative of the many styles of art in India. Reserving for a future article a detailed description of these interesting objects, it may be said that they have been executed by native workmen in India, at the expense of the Royal Commission supplemented by liberal grants from several of the native chiefs. They are mostly of an almost uniform height of about ten feet, and vary in length according to the amount of space occupied by the provinces to which they belong. In each court will be placed a skeleton map of India, with the particular province plainly indicated and all the principal towns in it shown. Visitors will thus be able to realise at a glance the special portion of the empire in which they are studying; and by this means they will be the more readily able to compare the products of the various provinces.

Some of the principal features of the Imperial Economic Court will be a raised map of India, prepared by Major Strahan, R.E., of the Survey-office; a model of an agricultural village from Lucknow, and trophies of various objects—*e.g.*, grain, paper, cotton, jute, silk, rope, dyes, gums, indigo, and lac; and a forestry archway, 15 feet high, and a bamboo bridge. In the court will be placed twelve ethnological groups representing the races of India; and near by, in the South Promenade, will be erected a Burmese pavilion.

The representation of the teas, coffees, and cocoas from India—together with those of Ceylon and the West Indies—will be placed in the North Court of the South Galleries, where a space 200 feet long has been set aside for the purpose. The exhibits will be shown in glass vessels, arranged in small courts, and subdivided into districts. The infused tea and coffee will be supplied to visitors, and the purity of the infusions will be ensured by the experienced and influential members of the committee appointed to represent, for this special purpose, India and the Colonies.

Tea, coffee, cocoa, and chocolate, will be sold in packets of various sizes in order that visitors may be enabled to test the qualities at their homes. A number of native attendants in their picturesque costumes, from India and Ceylon, will be stationed in the court.

The Indian tobacco-room is also situated in the North Court. The best growers and makers of cigars have responded to the invitation of the Government of India, and there will be a good display of the products of this rising industry. It is only of late years that the Indian cigar has been manufactured of a quality suited for use in Europe; but success has attended the efforts in that direction, and a large trade is now opening out. Cigars will be supplied to visitors, who will be enabled to test them in the Upper Gardens. In the vicinity of the band stands will be erected two kiosks where Indian cigars and Colonial cigars and cigarettes will be sold.

The shops in the forecourt of the Indian palace—the decorative woodwork for which is being carved in London by native workmen—will be filled with native artisans brought home in charge of Dr. Tyler. They will be genuine artisans, such as may be seen at work within the precincts of the palaces of some of the Indian princes. The following industries will be shown in practice:—Carpet weaving, wood-carving and turning, gold and silversmith's work, Delhi embossed copper work, brass founding, seal engraving, sweetmeat making, earthenware and glazed ware, stone carving, cotton printing and dyeing, silk weaving, Kincob weaving, clay figure making from Lucknow, and miniature painting.

It is confidently expected that the arrangement of the Colonial Courts this year will rebut the charge of want of interest which, at previous Exhibitions, has not unfrequently been brought against them.

A brief indication of what may be expected in some of the principal courts is given below.

CANADA.

All those who can call to mind the attractive and instructive manner in which Mr. Wilmot, and his fellow Executive Commissioners, arranged the Canadian Court at the International Fisheries Exhibition, will expect to find the Dominion this year no less prominently represented.

The President of the Canadian Commission is the Marquess of Lorne, K.T.; the Vice-President, Viscount Monck, G.C.M.G.; and the Executive Commissioner, the Honourable Sir Charles Tupper, G.C.M.G., High Commissioner; while any members of the Government of the Dominion who may be in London during the Exhibition will act as Honorary Commissioners.

The court will contain a collection of minerals, made by Dr. Selwyn and other officers connected with the Geological Survey statistics and specimens of the mineral wealth of Port Arthur; a classified collection of all the woods of the Dominion, supplemented by photographs showing the natural growth of the trees, and a trophy of woods and a valuable entomological collection. It will also contain very varied collections of fruits and grains, and an exhibit which will specially appeal to athletes and sportsmen—a selection of the different kinds of snow shoes, toboggans, lacrosses, and other implements used in Canadian sports, together with the photographs of the games and sports in progress; a collection made by Colonel Stockwell, of birds, minerals and roots from Anticosti; models of an ice palace and a dairy farm; and a collection of tobaccos grown in Canada.

There will also be an exhibit of a copy of every newspaper and periodical published in the Dominion.

Canada will be the only Colony which will have, to any extent, machinery in motion,

New South Wales.

The Earl of Rosebery is President of the London Commission for New South Wales, and Sir Daniel Cooper, Bart., is Vice-President. Sir Alexander Stuart, the Executive Commissioner, is on his way from Sydney; and, pending his arrival, Sir Daniel Cooper and Sir Saul Samuel, the Agent-General for the Colony, are Acting Commissioners—assisted by Mr. G. C. Levey, C.M.G. The Commission in Sydney numbers no less than seventy-six members, with Sir James Martin as President. It contains amongst other prominent men in the colony the President of the Legislative Council, the Speaker of the Legislative Assembly, the Minister of Justice, the President of the Chamber of Commerce, the Minister of Public Instruction, the Director of the Botanic Gardens, the Curator of the Australian Museum, the Government Astronomer, the Geological Surveyor, the Surveyor General and the Government Examiner of Coal Fields.

Up to the 20th of January, no less than 1,176 packages had been shipped from Sydney for the New South Wales Court.

All the industries of the colony will be duly represented—especially wool, minerals, leathers, oils, and wines. The Department of Mines will exhibit a large collection of specimens of gold, copper, tin, and antimony, and fossils showing the geological formation of the colony. Timber will be shown both in the rough and manufactured; and dining and bedrooms will be seen containing ordinary furniture and billiard tables. The fisheries will be represented by specimens in spirits and by pictures. Access to the court will be through a triumphal arch, and painting, sculpture, and photography will be well represented. The last-named will include views of the most beautiful scenery and the finest buildings in the colony.

Victoria.

The President of Melbourne Commission for Victoria is Mr. Joseph Bosisto, and amongst the twenty-four other members of the Commission are, the Mayor of Melbourne and the Presidents of the Ballarat Agricultural and Pastoral Association, the National Agricultural Society, the Melbourne Chamber of Commerce and the Chamber of Manufactures. In London the colony is represented by Mr. Murray Smith, C.M.G., Agent-General, as Executive Commissioner, and Mr. James Thomson, as Secretary.

It is estimated that there will be about five hundred exhibitors and little short of eleven thousand exhibits in the Victorian Court alone, which is being prepared under the immediate superintendence of Mr. Bosisto (who has recently arrived in London), and Mr. Thomson. Victoria, like New South Wales, is approached through a triumphal arch. The most attractive features will perhaps be the fern gully, for which a conservatory is being erected in the Central Avenue, and the aviary of the birds of the colony. Examples of Victorian timber of every description will be shown by the Technological Museum, by Baron Von Müller, Government Botanist, and others. Baron Von Müller will also contribute a collection of rare plants in albums. Moths, butterflies, beetles, and other insects, will be represented. There will be specimens of pure Merino sheep from the Carngham Stud Flock, and many varieties of wool. Mr. Guilfoyle, the Director of the Melbourne Botanic Gardens, will contribute collections of fibres and carpological specimens, and Professor McCoy will send a large selection of examples of natural histroy.

A collection of Eucalyptus, and other preparations from the indigenous vegetations of Australia, will be contributed by Mr. Joseph Bosisto. There will also be collections of articles made by the Aborigines of Victoria, by the School for the Blind, and of articles prepared under the direction of the Penal Department of Victoria, and a model of Quarantine Station exhibited by the Central Board of Health. Pottery ware, wood ware, saddlery and harness, tweeds, blankets and flannels, furs, gold specimens from the celebrated Rowe Brothers mine at Fryerstown, and the Sandhurst mines, specimens of steel and copper engraving, of stereotyping, and of bookbinding and printing will be seen in the court, which will further contain many oil and water-colour paintings, supplemented by numerous photographs.

The Victorian Commission, in Melbourne, has made special efforts to secure a full and complete representation of the wines of the colony; and in the cellars of the Royal Albert Hall and in the court will be many hogsheads of different varieties.

Mr. Thomson has brought over with him, as attendants in the court, two native boys who are proficient in the purely Australian art of boomerang throwing.

At the meeting of the Common Council, on March 11th, Mr. W. H. Pannell, Chairman of the Colonial and Indian Reception Committee, brought up a report expressing the opinion of the Committee that the visit to this country of the Colonial and Indian Representatives on the occasion of the coming exhibition would be, so far as the Corporation were concerned, most appropriately recognised by a service in St. Paul's Cathedral, at which the Lord Mayor and the Corporation should attend in state, and by a reception and ball to be given in the Guildhall, and the committee recommend that they should be authorised to make and carry out the necessary arrangements at a cost not exceeding £3,000. After some discussion the report was adopted.

ELECTRIC LIGHTING.

The following memorandum accompanies Lord Rayleigh's Electric Lighting Act (1882) Amendment Bill, which has just been printed:—"The main object of this Bill is to amend the Electric Lighting Act, 1882, so as to place electric lighting undertakings in the same position as gas undertakings both as regards privileges and obligations. The chief provisions are:—1. That where electricity is not ascertained by meter, the consumer shall not use any lamp other than such as has been provided or approved of by the undertakers, or any lamp calculated to expend more electricity than he has contracted to pay for. This is done by clauses 3 to 6 of the Bill, which in effect re-enact (*mutatis mutandis*) the sections 18 to 20 of the Gasworks Clauses Act, 1847, without the exception as to the use of burners made by section 12 of the Electric Lighting Act, 1882. 2. Section 18 of the Electric Lighting Act, 1882, which expressly prohibited the undertakers from prescribing any special form of lamp or burner, is repealed, and instead, the proviso that where electricity is supplied by meter no local authority or person shall be at liberty to use any form of lamp, or use the electricity supplied so as to interfere with the proper supply to other persons, is re-enacted substantively. (Clause 7.) 3. Section 27 of the Electric Lighting Act, under which local authorities may, after the expiration of 21 years, purchase the undertaking by paying the then value of all suitable lands, buildings, works, &c., of such undertakers, without any addition in price, in respect of compulsory purchase, or of goodwill, or of any profits, is repealed. (Clause 8.) 4. The profits of undertakers are limited to the rate prescribed by the provisional order or special Act, or where no rate is prescribed, to 10 per cent. per annum. The principle whereby dividends are increased or diminished in inverse ratio to increase or diminution of price is introduced on the method of the sliding scale applied to gas undertakings, except that having regard to the small price charged per electrical unit as compared with the price charged per 1,000 cubic feet of gas, the dividend is increased or reduced by 5s. per £100 in respect of every one farthing instead of 1d., as in the price of gas. (Clause 9.) 5. New or additional capital in the undertaking to be offered to the public by auction, in accordance with the usual auction clauses applied to gas undertakings. (Clause 10.) 6. The undertakers are to furnish a sufficient supply of electricity to owners or occupiers situate within twenty five yards from the main. (Clause 11.) 7. The undertakers are to supply electricity for public lamps. (Clause 12.) 8. Mains are to be kept fully supplied. (Clause 13.) 9. Penalties similar to those of the Gas Acts are provided in case of default by the undertakers. (Clause 14.) 10. Local authorities to have similar powers of acquisition of the undertakings by agreement as are given them in the case of gas by the Public Health Act, 1875, section 162. (Clause 15.) 11. Penalties to be recovered summarily. (Clause 16.)"

MINING INDUSTRIES OF GERMANY.

Germany possesses a vast and almost inexhaustible supply of fossil fuel, for the most part of excellent quality, and the *Adress-Buch Deutscher Export-Firmen* states that the following are the most important sources of coal supply. The coal basin of the Lower Rhine and Westphalia, generally termed the Ruhr Basin, which covers an area of about 2,900 square kilometres, and has been estimated to contain 55,000,000,000 tons of coal; the coal-fields near Aix la Chapelle producing annually on the average one and a half million tons; the coal basin of the Saar in the south-west district of the Rhenish province, in the Bavarian Palatinate, and in the eastern portion of Lorraine, estimated to contain 45,000,000,000 tons of coal, and producing annually 6,000,000 tons; the coal-fields of Upper Silesia (Königshütte), with an area of 480 square kilometres, containing about 50,000,000,000 tons, and an annual output of

11,000,000 tons; the coal-fields of Saxony and the coal basin of Lower Silesia (Waldenburg) with an annual output of 3,000,000 tons. Brown coal or lignite, although found in large quantities in Middle Germany, from Silesia to the Rhine, has but little importance for export, and it is mostly of inferior quality. The brown coal found in the province of Saxony (Weissenfels) is remarkable as having formed the foundation of a strongly developed industry in the lighter and heavier sorts of coal tar oils, and their further treatment. The total production of coal, throughout the whole of the German Empire, amounted in 1881 to 48,688,164 tons, valued at £12,613,000, and of lignite to 12,852,000 tons, with a value of £1,906,000. Pit coal is exported from Upper Silesia to Austria and to Russia, and from the districts of the Rhine and the Saar to the Netherlands, France, Belgium, and Switzerland. Considerable quantities have also recently been exported to Italy, owing to the opening of the St. Gothard Railway, and finally to the seaports of Germany and the Netherlands for transport to Denmark, Sweden, and Norway. The tota amount of coal exported in 1881 amounted to 7,458,246 tons, and of coke 430,272 tons. The ore which is of most importance in the German export trade is the iron ore, more especially the iron ore of Luxembourg, and that exported from Lorraine to Belgium and France. In 1881 the amount of iron ore produced was 7,573,000 tons, valued at £1,804,000; and the amount exported 1,443,000 tons. Of the total output about 35 per cent. is brown hematite, from the Rhenish Province, Silesia, Luxembourg, Lorraine, and Hanover; about 25 per cent. of spathose iron ore from the Rhenish Province, Westphalia, Siegerland, Thuringia, and Wurtemburg; 18 to 20 per cent. of black band in Rhenish Westphalia, Silesia, and in the coal districts of the Saar; 9 to 10 per cent. of red hematite in Nassau, Siegen, Wetzlar, Hesse, Saxony, and Thuringia. The remainder consists of magnetic iron ore, frequently found, but seldom in large beds; of clay iron ore found in Luxembourg, Lorraine, on the Rhine Westphalia, and Silesia; and of the bog iron ore found in the lowlands and in the Northern plains. Of the other ores, such as silver, tin, zinc, cobalt, nickel, manganese, &c., large quantities are obtained, but very little is exported. Of lead and copper ores only 2,756 tons were exported in 1881. As regards mineral salts, the most important of these are rock and common salt, in both of which Germany is very rich, there being still unexplored, very thick beds of rock salt in the provinces of Brandenburg, Posen, Hanover, and in many districts of the plains of Northern Germany. Besides these, there are the famous Cainite and other potash and bitter salts in the province of Saxony (Stassfurt), and in the Duchy of Anhalt, of which considerable quantitities are annually exported. In the year 1881 the production of rock salt amounted to 312,000 tons; of common salt to 457,000 tons; cainite to 161,000; other potash salts to 745,000; and chloride of potassium to 113,000 tons; while the quantity of common salt exported during the same year amounted to 185,000 tons.

A NEW BOXWOOD.

By John R. Jackson, Curator of the Museums, Kew.

In connection with the subject of boxwood and its substitutes (see *Journal of Society of Arts*, April 10 and 17, 1885), a brief account of the discovery in South Africa of a new species of boxwood will, no doubt, be of interest to the readers of the *Journal*.

In the spring of last year a correspondent at East London, Cape of Good Hope, wrote me to the effect that he had a considerable quantity of Cape boxwood and other hard woods growing on his farm, which he was anxious to turn to some account if the wood was really valuable for engraving purposes, and asking for the name of some London firm to whom samples could be sent, with a view of introducing it to the market. To this I replied, giving the name of a well-known firm, and asking that a good sample might be sent for the Kew Museum. Later on, a specimen was received, together with small specimens of the foliage. Upon comparison of this foliage and wood with those of *Celastrus buxifolius*, L., which is generally known as Cape box, it was found that they did not agree, and upon a more careful examination of the wood, and comparing it with true box, the two woods were found to be nearly identical, and the foliage itself came very near to that of *Buxus sempervirens;* it was, therefore, clearly a species of *Buxus*, and probably *B. sempervirens* itself, which had perhaps been introduced into the colony. The tree was described by the sender as growing to an average height of about 30 feet, and as a rule not exceeding twelve to fourteen inches in diameter. The principal of the firm to whom samples of the wood were sent for trial writes thus:—"I have had pieces distributed amongst six practical men, and though they all report favourably of its appearance, they unite in saying that it does not cut smoothly, but harsh and ragged, and that the cutter 'blurrs' on the wood, whereas genuine box cuts quite smoothly. There is also a nasty tendency to split from the centre outwards instead of the clean way in which boxwood splits, so that the end of every piece has a series of star-shakes. In addition, every log I have cut has very many black specks, quite spoiling it for first-rate work, even if good in other respects."

Nothing more was heard of boxwood from the Cape until the following paragraph appeared in the *Indian Forester*, for November last:—"Among the recent arrivals we notice a sample parcel of Cape boxwood delivered at the West India Dock per *Warwick Castle*, consisting of fifty-five pieces, weighing nearly three tons. The logs are of good sizes, sound and clean grown. This wood possesses a closeness of grain almost equal to the best Abassian boxwood, and it is thought will suit admirably for engravers' purposes. From the specimens of this wood, and engravings printed from it, which were shown at the Forestry Exhibition, at Edinburgh, last year, it would appear to be one of the best hard woods yet put forward as a substitute to supply the demand for the ever diminishing supply of boxwood."

At the end of December last, specimens were received at Kew from Capetown of the plant, the wood of which it was said was then being cut in the Kaffraria forests as a substitute for box. In the Forests Reports it seems the surveyors refer to it as Cape box, and naturally concluded it was *Celastrus buxifolius*, but upon examination at Kew it has been proved to be a new species of *Buxus*, and has been named by Professor Oliver *Buxus macowani*, in honour of Mr. P. Macowan, Director of the Botanic Garden, Cape of Good Hope.

COOKING BY MACHINERY.

The *Scienza per Tutti*, of Milan, gives a description of the machinery and appliances used at the Restaurant Marguery, on the Boulevard Bonne Nouvelle, Paris. The basement of this establishment consists of two floors below the level of the street, which contain, besides very extensive cellars, kitchens, and larders, the various labour-saving machines; these consist principally of machines for crushing and reducing to pulp, washing machines, machines for cleaning knives, bottles, and plates, for roasting meat, &c., and also for roasting coffee. These machines are driven by a gas-engine, and a second engine is kept in readiness in case it should be required. Some of the machinery is driven by belting from shafting, whilst others receive their motion by means of electricity supplied by a Gramme machine. The machine for crushing bones, lobsters, pulping meat, carrots, potatoes, beans, &c., consists of two discs revolving vertically in opposite direction, which discs are furnished with a number of radial teeth, so that when in motion the bones or other substances put into a hopper above are crushed between them, the degree of fineness being regulated by a set screw, by means of which the discs are brought further or more apart. The machine for washing consists of a fine sieve, through which the *puré* is made to pass by means of flat stiff brushes carried on arms projecting from a vertical shaft revolving above it. The roasting machines for coffee and for meat are driven by belting from a counter shaft, the number of revolutions and degree of cooking being regulated to a nicety by the cook's assistants, who know the exact amount of time required.

The machine for washing plates deserves particular attention. It consists of a circular trough, divided into two compartments, one for hot, and the other for cold water, which latter is being constantly renewed. Above this trough revolves a vertical axle, which carries just above the water level a ring, hinged to which are eight curved arms, the extremities of which are provided with a kind of three-jawed clip, which seizes the plate, and holds it tightly by the rim. Above the level of the water is an annular guide bar, bent in such a way that when the machine is in motion the jointed arms, which pass over it carrying the plates, are depressed, and the plates alternately dipped into the hot water, turned in a vertical position whilst they are passed between brushes, which effectually clean them on both sides. They are next lifted out of the water, and then plunged suddenly into the cold water tank, from which they come out perfectly clean, and are taken off by an assistant and put on a rack, in order that the water may drain off, and finally are wiped dry. This machine is capable of washing 4,000 plates per day.

The machine for washing bottles is also very ingenious, and is driven by an electro-motor. The four bottles which are washed at the same time are fixed on spindles, which cause them to revolve at the rate of 300 revolutions per minute, under a stream of water at high pressure between brushes which press against the sides externally and internally. The bottle only remains 32 seconds in the machine, during which time it has made 180 revolutions against the brushes, which do not fail to clean it effectually. Previous to adopting the machine, two men and one boy were required to wash from 700 to 800 bottles per day. Now no fewer than 400 per hour can be cleaned, and this with a far smaller percentage of breakage than in the usual way. The machine is exceedingly simple, and can be easily taken to pieces and cleaned. The brush used for cleaning the inside of the bottle is fixed upon a flexible bar, and is forced against the sides by an india-rubber spring.

THE CULTIVATION OF LICORICE IN SICILY.

Consul Woodcock, of Catania, says that there are two species of the licorice plant in his consular district. The one sends down a main root to the depth of from three to six feet, with but few lateral roots; the other does not sink so deep in the earth, but creeps beneath the surface at a depth of from six inches to two feet, the latter being most productive, and the most highly prized. It is stated that if the licorice plant were cultivated, instead of being allowed to grow wild, it would yield much larger results; but the Sicilians are of opinion that its culture will not pay, so they are satisfied by collecting it as produced by nature in its wild state. No use is made of the stem except for fuel. The licorice plant grows most luxuriantly in the valleys adjacent to streams of water; it is, however, found among the foot hills of the mountains, but grows less luxuriantly there. It requires a moist soil, consisting of a clay loam; the climate must be warm, such as is adapted to the growth of oranges, lemons, and other semi-tropical fruits. It cannot endure frosts, or cold, high altitudes. The root continues to grow for four or five years, when it is considered in the best condition for gathering. The root will continue to grow for ten or twelve years longer, but it is not considered so rich in juice-yielding quality. The crop is gathered from the same ground once in four or five years, and on the average 100 pounds of the root produces sixteen pounds of licorice paste. During the months of June, July, August, and September, and the first part of October, the root is not disturbed for the reason that it is then in full vegetation, and for the further more important reason that the ground is dry and baked by the sun, and it is with much difficulty and great expense that it can then be dug. As soon as the autumn rains set in in sufficient quantity to saturate the ground, the root harvest commences. During the months above-mentioned the manufactories of licorice are idle, doing little or nothing in the way of manufacture. In Catania itself there are seven manufactories of licorice, which employ from twenty to forty hands each. When the roots are taken from the earth, they are bound in bundles and carried on the backs of mules from the fields to the factories, where they are laid by for a time to season. When the roots are sufficiently cured, men and women with hatchets cut them in pieces ranging from three to six inches in length. These are then plunged into a vat of water and thoroughly washed. They are then crushed in a mill of rude construction. It consists of two circular stones of lava, one in horizontal position, and the other, which is perpendicular, resting upon it. Through the centre of the upper stone is an axle, to which is attached a mule, which revolves it slowly in a circle upon the lower stone. A workman with a wooden shovel is constantly employed in keeping the roots beneath the revolving stone. When the roots are sufficiently crushed, they are placed with water in kettles and boiled for twenty-four hours. They are then removed from the kettles and placed beneath a screw press, and all the juice, which is thoroughly pressed out, runs into a cistern beneath. This juice is pumped from the cistern and passed through a sieve into kettles and the boiling resumed. The sediment from the strainer is again pressed; the contents of the boiling kettles is a second time filtered. When boiled to the proper consistency, it is removed to a broad shallow kettle over a slow fire, where workmen, with spades, continue to stir it until it becomes dense enough for paste; it is then removed and placed in wooden moulds of the size they wish the cakes, or worked by the workmen into little rolls or sticks. When cold and hard, the cakes are wrapped in paper and boxes for export. The little rolls or sticks of licorice are placed upon shelves to dry, and when they become perfectly dry and hard, they are packed in laurel leaves in boxes. In preparing the root for market, women, with knives, scrape off the bark, and then cut it into pieces of about half an inch in length, or as desired by the purchaser. These are then dried in the sun, and placed in bags for export.

KING OF THE BELGIANS' PRIZE.

A prize of 25,000 francs, or £5,000, is offered every year by Leopold II., now sovereign of the Congo Free State as well as the King of the Belgians, for the best essay on some predetermined subject tending to advance the well-being of mankind. The competition is alternately restricted to Belgians, and thrown open to the whole world, being settled by an international jury. The subject of this year's competition, open to the whole world, was "The Best Means of Improving Sandy Coasts;" and the prize has been awarded by an international jury, including some of the most eminent English and French engineers, to M. De Mey, engineer of Ponts et Chaussées, Bruges, against 59 competitors. This is only the second time that the international prize has been awarded, that in 1880, the year that the prize was instituted, having been adjudged to M. A. Wauters, archivist to the Brussels Municipality, for his "History of the Origin of Communal Franchise in Belgium." The subject for the essay at the next international competition is "The Progress of Electricity Applied to Motive Power and Illumination, its Applications and Economical Advantages." The essays for competition, which must be written in French, or translated into that language, are to be sent before the 1st January, 1889, to the Minister of Agriculture, Industry an Public Works, from whom the conditions of the competition may be obtained.

METAL WORK OF THE BURMESE.

Both Burmans and Shans are expert blacksmiths. The latter forge all the *dahs* (native hatchets) used by themselves and their neighbours in the Hotha valley, and they annually resort to Bhamo, and the villages in the Kakhyen hills, for the purpose of manufacturing them. Their bellows are of the most primitive stamp, consisting of two segments of bamboo, about 4 inches in diameter and 5 feet long, set vertically, forming the cylinders, which are open above and closed below, except by two small bamboo tubes, which converge and meet at the fire. Each piston consists of a bunch of feathers, or other soft substance, which expands and fits tightly in the cylinder while it is being forcibly driven down, and collapses to let the air pass as it is being drawn up. A boy, perched on a high seat or stand, works the two pistons alternately, by the sticks serving as piston rods. Charcoal is used for fuel.

The casting of large and small articles in brass, bronze, and other alloys, is much practised, always adopting the method known as *à cire perdue*. First a clay model is made, and coated with bees wax to the thickness of the intended cast, and again covered with an outer skin (2 inches thick) of clay, mixed with finely-chopped straw; this latter coat is provided with funnel-like holes, for pouring in the molten metal, at intervals of 4 inches, and with straw-holes for letting out imprisoned air. Holes are also provided at the bottom for the escape of the melted wax.

Correspondence.

ELECTRICAL DISTRIBUTION.

On reading over the paper which I read to the Society of Arts on February 17th last, "On Some Points in Electrical Distribution," I find that, when speaking of secondary generators, there is an omission which may be apt to mislead. When treating of the arrangements of these generators *in parallel*, my remarks in the body of the paper have reference only to such generators as those which have been specially under my notice—where the difference of potential at the terminals either of the primary or secondary circuit is not so great as thousands of volts. I feel that I ought to have taken some notice of those generators in which the difference of potentials of the primary may be several thousand volts. In this case, of course the fall of potential in the main conductors is of far less moment. There a distance of a mile causes as little trouble as does 100 yards in a direct supply. The ratio of the maximum values of the difference of potentials at the terminals of the primary and secondary coils may be expressed by the following relation:—

$$\frac{V^2}{V'^2} = \frac{\rho^2 + 2\rho\, r' + r'^2}{\rho'^2 - 2\rho'\, r' + r'^2} + \frac{\rho^2\, r'^2}{(\rho'^2 - 2\rho'\, r' + r'^2)\, C^2}$$

Adopting the same notation as in the appendix to my lecture.

Now, r' is always very large compared with ρ', and ρ is large compared with r' in the present case. Hence, this reduces to $\frac{V^2}{V'^2} = \frac{\rho^2}{r'^2} + \frac{\rho^2}{C^2}$ approximately.

If C^2 be small compared with r'^2, then we might have $\frac{V^2}{V'^2} = \frac{\rho^2}{C^2}$ a constant. Hence it appears that, with a generator the resistance of whose secondary circuit is large, and the resistance of the primary coil large even when compared with that, we may attain constant *emf* in the lamp circuit by maintaining constant pressure at the terminals of the primary, and (in the case where the *emf* of the dynamo is very great) this may be attained by keeping the *emf* at the terminals of the dynamo constant.

I have seen no experiments to judge how far this approximation has been reached in actual practice, but I have been promised to inspect such an arrangement shortly.

GEORGE FORBES.

P.S.—Please notice the following erratum in the appendix to my paper. In the expression for V'^2—*for* $(r' + \rho')^2$ *read* $(r' - \rho')^2$. G. F.

HARBOURS OF REFUGE.

We have no harbour of refuge on the coasts of England that is worth the name. There is a beautiful site at no great distance from the metropolis, and it is surprising that no attention is paid to it. I allude to Pegwell Bay, between Ramsgate and Sandwich. Here a harbour can be formed embracing the whole of the Downs as an entrance, and the Stour Estuary can be excavated as far as Canterbury if necessary; the land is now a marsh, and used for grazing purposes. There is a magnificent back water, and no engineering difficulties are to be found. It is commanded by two railways, and the scheme, if carried out, would relieve the overcrowded Thames, and the avoidance of many dangers would enhance its value to all engaged in the shipping interests of the United Kingdom. I most earnestly ask your attention to this grand scheme, as a means of finding labour for the starving unemployed thousands on a work urgently needed, on a site so much better and so well adapted than any other. The Dover harbour, as a harbour of refuge, is simply absurd. The money that has been wasted for years on this place might have been more judiciously expended at the site known as Pegwell Bay. Dover will never have a harbour of refuge; the configuration of the land will not admit of it. There is only sufficient space and convenience for Continental steamers.

T. W. AYLESHUM,
Commander, late Indian Navy.

Sutton, March 6th, 1886.

General Notes.

BRONZE CASTING IN BELGIUM.—A full report by Sir J. Savile Lumley on Bronze Casting in Belgium was published in the Consular Reports, on subjects of commercial and general interest. Part I. (Commercial No. 2, 1884.) Sir J. Savile Lumley gives an historical account of bronze casting, and description of the processes of manufacture. The report can be seen by members in the Society's Library.

CONGRESS ON INTERNAL NAVIGATION.—During the Congress held at Brussels in May last, the engineer Di Gioia, delegate of the Italian Government, described a method of planting the banks of the Suez Canal with date palms, in order to consolidate them. With reference to this subject, as reported in the *Journal*, vol. xxxiii., p. 908. Mr. W. J. Addis, civil engineer, at Maulmain, British Burmah, wrote to the President of the Congress that he had found the *Andropogon shoenanthus*, a species of palm, the best plant for this purpose. It will grow readily from a single root, and should be lopped six months after being planted. The loppings constitute an excellent material for paper-making, and easily fetch £4 5s. a ton for this purpose in India.

TURKISH WINE.—A recent number of the *Journal de la Chambre de Commerce de Constantinople* gives some particulars respecting wine growing in Turkey. The demand for the wine of that country has considerably increased of late, and more particularly last year. The produce of the vineyards situated between Cadi-Kaû and Pendah was, for the greater part, purchased at comparatively high prices by French importers. The exports from this district which, in 1884, amounted to 760,000 okes, to the value of 8,050 Turkish pounds, reached in the following year to 1,600,000 okes, to the value of 22,000 Turkish pounds; whilst the red wines of Kizil and Raprak, which were formerly paid, on the average, at the rate of 1¼ piastre per oka, fetched on the spot, last year, prices varying from 2 to 2½ piastres. The French purchasers were not limited to the above-mentioned districts, but large quantities of wine were exported from other provinces.

PRODUCTION OF COAL IN RUSSIA.—The production of coal in the Russian empire has increased considerably during the last ten years, as is shown by the following statistics:—

1873	puds	71,586,328.
1874	,,	78,795,093.
1875	,,	104,772,688.
1876	,,	111,299,028.
1877	,,	108,137,094.
1878	,,	153,981,727.
1879	,,	178,238,013.
1880	,,	200,784,874.
1881	,,	213,258,477.
1882	,,	210,193,536

The production of coal in Russia is, however, very small indeed, when compared with the immense area of that empire, as that of Great Britain, in 1883, amounted to not less than 9,689,693,036 puds; that of Germany to 3,531,623,487 puds; whilst Belgium produced 1,073,050,329 puds. With a greater extension of the railway system, so that the centres of production would be put in communication with those of consumption, a large development might be given to that industry.

MEETINGS OF THE SOCIETY.

ORDINARY MEETINGS.

Wednesday evenings, at Eight o'clock:—

MARCH 24.—"Domestic Electric Lighting." By W. H. PREECE, F.R.S. Sir FREDERICK ABEL, D.C.L., C.B., F.R.S., Chairman of Council, will preside.

MARCH 31.—"Methods for rendering the Blind Self-supporting." By T. R. ARMITAGE, M.D.

APRIL 7.—"Preparation of Drawings for Photographic Re-production." By J. S. HODSON.

APRIL 14.—"The Treatment of Sewage." By Dr. C. MEYMOTT TIDY. Sir FREDERICK ABEL, D.C.L., C.B., F.R.S., will preside.

FOREIGN AND COLONIAL SECTION.

Tuesday evenings, at Eight o'clock:—

MARCH 23.—"Canada and its National Highway." By ALEXANDER BEGG. Sir CHARLES TUPPER, G.C.M.G., will preside.

APRIL 13.—"The Progress of the British Possessions in the last quarter of a century." By P. L. SIMMONDS.

MAY 6.—"The Commerce and Industries of New South Wales." By EDWARD COMBES, C.M.G., President of the Board of Technical Education of New South Wales.

APPLIED CHEMISTRY AND PHYSICS SECTION.

Thursday evenings, at Eight o'clock:—

MARCH 25.—"Certain Methods for the Utilisation of Refuse and Dust Fuels." By WALTER G. MCMILLAN, F.C.S., Demonstrator of Metallurgy, King's College, London.

APRIL 8.—"Asbestos and its Applications." By JAMES BOYD.

MAY 13.—"The Scientific Development of the Coal Tar Colour Industry." By Professor R. MELDOLA, F.C.S.

INDIAN SECTION.

Friday evenings, at Eight o'clock:—

MARCH 19.—"Experiences on the Afghan Frontier." By WILLIAM SIMPSON.

APRIL 2.—"The History of Archæology in India." By JAMES GIBBS, C.S.I., C.I.E., late Member of the Viceroy's Council. Sir GEORGE BIRDWOOD, C.S.I., Member of the Council, will preside.

MAY 7.—"Indian Manufactures from a Practical Point of View." By B. H. BADEN POWELL, C.I.E. The Right Hon. Lord HARRIS will preside.

MAY 21.—"Everyday Life of Indian Women, as revealed in their own sayings." By Capt. RICHARD CARNAC TEMPLE.

The above dates are liable to alteration.

CANTOR LECTURES.

The Fourth Course will be on "Petroleum and its Products." By BOVERTON REDWOOD F.C.S.

Lecture III.—March 22.—Manufacture of Petroleum Products:—Naphtha, Burning Oil, Lubricating Oil, Paraffin. Methods of distillation and purification. Barrel and case making. Testing:—Flashing point, viscosity, lubricating power, melting point.

Lecture IV.—March 29.—The uses of Petroleum and its products. Illumination:—Paraffin candles, mineral oil and spirit lamps, air-gas, natural gas. Heating:—Crude Petroleum and Petroleum residuum as fuel, mineral oil stoves. Natural gas as fuel. Lubrication. Pharmaceutical.

ADDITIONAL LECTURES.

Six Elementary Lectures on "Electricity" will be delivered by Professor GEORGE FORBES, on Saturday afternoons, at Three o'clock:—

Lecture I.—April 3.—Electromotive Force and Potential.

Lecture II.—April 10.—Currents and Resistance.

Lecture III.—May 1.—Magnetism.

Lecture VI.—May 8.—Electro-magnetic Phenomena.

Lecture V.—May 15.—Induction.

Lecture VI.—May 22.—Electrical Measurement.

Tuesday evenings, at Eight o'clock:—

"Japanese Art Work." BY ERNEST HART.

Lecture I.—May 4.—Japanese Metal Work.

Lecture II.—May 11.—Japanese Porcelain and Pottery.

Lecture III.—May 18.—Japanese Picture Books and Drawings.

The rules of admission to these Lectures will be the same as for the Cantor Lectures. Each member has the right of admission for himself and one friend.

Tickets available for all the Society's meetings were supplied to all the members at the commencement of the Session.

MEETINGS FOR THE ENSUING WEEK.

MONDAY, MARCH 22...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. (Cantor Lectures.) Mr. Boverton Redwood, "Petroleum and its Products." (Lecture III.)

Surveyors, 12, Great George-street, S.W., 8 p.m. Mr. William Matthews, "The Taxation of Real Property."

Geographical, University of London, Burlington-gardens, W., 8½ p.m. Mr. J. Annan Bryce, "Burma: the Country and the People."

Medical, 11, Chandos-street, W., 8½ p.m.

East India Association, Exeter-hall, Strand, W.C., 3 p.m. Mr. Nanda Lal Ghosh, "The Coming Inquiry into the Administration of India."

TUESDAY, MARCH 23...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. (Foreign and Colonial.) Mr. Alexander Begg, "Canada and its National Highway," illustrated by Lantern Views.

Royal Institution, Albemarle-street, W., 3 p.m. Prof. A. Gamgee, "New Function of Circulation." (Lecture III.)

Medical and Chirurgical, 53, Berners-street, Oxford-street, W., 8½ p.m.

Civil Engineers, 25, Great George-street, S.W., 8 p.m. Discussion on papers by Messrs. R. Gordon, J. R. Mosse, and G. C. Cuningham on "The Economical Construction and Operation of Railways in newly-developed Countries, or where small returns are expected."

Anthropological, 3, Hanover-square, W., 8½ p.m. Capt. C. R. Conder, "The Present Condition of the Bechuana, Koranna, and Matabele Tribes."

Horticultural, South Kensington, S,W. Promenade Show.

WEDNESDAY, MARCH 24...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. Mr. W. H. Preece, "Domestic Electric Lighting."

Geological, Burlington-house, W., 8 p.m. 1. Mr. James Thomson, "The Genus *Diphyphyllum*, Lonsdale." 2. Dr. W. T. Blanford, "Additional Evidence of the occurence of Glacial conditions in Palæozoic times, and on the age of the beds containing plants of Mesozoic type in India and Australia." 3. Mr. G. W. Lamplugh, "Glacial Shell-beds in British Columbia."

Royal Society of Literature, 4, St. Martin's-place, W.C., 8 p.m.

Civil and Mechanical Engineers, 7, Westminster-chambers, S.W., 7 p.m. Mr. B. Haughton, "Wave Motion."

THURSDAY, MARCH 25...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. (Chemical and Physical Section.) Mr. Walter G. McMillan, "Certain Appliances for the Utilisation of Refuse and Dust Fuels."

Royal, Burlington-house, W., 4½ p.m.

Antiquaries, Burlington-house, W., 8½ p.m.

Royal Institution, Albemarle-street, W., 8 p.m. Prof. Dewar, "Electro-Chemistry." (Lecture I.)

Telegraphic Engineers and Electricians, 25, Great George-street, S.W., 8 p.m. Paper on Electric Lighting by means of low resistance glow lamps.

FRIDAY, MARCH 26...United Service Institute, Whitehall-yard, 3 p.m.

Civil Engineers, 25, Great George-street, S.W., 7½ p.m. (Students' Meeting.) Mr. William Andrew Legg, "The Construction of the Hirnant Tunnel on the Line of Aqueduct of the Vyrnwy Waterworks for the supply of Liverpool."

Royal Institution, Albemarle-street, W., 8 p.m. Weekly Meeting, 9 p.m. Professor W. Chandler Roberts Austen, "Certain Properties Common to Fluids and Solid Metals."

Quekett Microscopical Club, University College, W.C., 8 p.m. Papers by Messrs. Michael, Morland, and Nelson.

Clinical, 53, Berners-street, W., 8 p.m.

Browning, University College, W.C., 8½ p.m. Mr. Arthur Symons, "Browning's Metrical Development especially in regard to Blank Verse."

SATURDAY, MARCH 27...Physical Science Schools, South Kensington, S.W., 3 p.m. Professor S. P. Thompson, "An Arc Lamp Suitable for the Duboscq Lantern."

Botanic, Inner Circle, Regent's-park, N.W., 3¾ p.m.

Royal Institution, Albemarle-street, W., 3 p.m. Mr. Howard Grubb, "The Astronomical Telescope." (Lecture I.)

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FRIDAY, MARCH 26, 1886.

All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

NOTICES.

CANTOR LECTURES.

The third lecture of the Course on "Petroleum and its Products," was delivered at the Society of Arts, on Monday evening, 22nd inst., by Boverton Redwood, F.I.C., F.C.S. The lecturer demonstrated by diagrams, specimens, and experiments, the processes of manufacturing the various commercial products from crude petroleum and shale, and quoted statistics showing that the outturn of burning oil from the refineries of the United States and Russia amounted, for the year 1885, to about 586,000,000 imperial gallons, and about 118,800,000 imperial gallons respectively. Of the oil manufactured in the United States nearly 203,000,000 imperial gallons were consumed in the country, and the remainder was exported in 6,985,657 barrels and 16,528,844 cases. These barrels weighed collectively more than 1,222,000 tons. If piled six high they would cover a space of about half a square mile, and if placed end to end would extend for 3,638 miles. The tin employed in the manufacture of the cases weighed more than 38,000 tons, and would cover more than five square miles. The lecturer dealt with the methods of distribution of the products, and described in detail the making of barrels and cases by machinery, mentioning that a single factory in the United States turned out per day 10,000 finished barrels, and another 30,000 wooden cases, each containing two tins.

The representative collection of specimens and apparatus used in illustrating the lectures will remain open to inspection in the Society's rooms during the ensuing fortnight. After Monday next the collection will include all the principal forms of mineral-oil lamps and stoves. Any person interested in petroleum manufacture can obtain admission by applying to the Secretary of the Society of Arts.

The lectures will be published in the *Journal* during the summer recess.

WESTGARTH ESSAYS.

The three essays by W. Woodward, H. H. Bridgman, and J. Corbett, to which the prizes offered by Mr. William Westgarth were awarded by the Society of Arts in 1885, are now published under the title of "Essays on the Street Re-alignment, Re-construction, and Sanitation of Central London, and on the Re-housing of the Poorer Classes." The volume is published by George Bell and Sons at 15s., but copies can be obtained by members of the Society of Arts for 10s. each, on application to the Secretary.

PRACTICAL EXAMINATION IN VOCAL AND INSTRUMENTAL MUSIC.

The next examination in London will be held by Mr. W. A. Barrett, Mus.Bac. Oxon, at the House of the Society of Arts, 18, John-street, Adelphi, W.C., during the week commencing Monday, 24th May, 1886.

Full particulars can be obtained on application to the Secretary.

Proceedings of the Society.

APPLIED CHEMISTRY & PHYSICS SECTION.

Thursday, March 11th, 1886; Capt. W. de W. Abney, F.R.S., in the chair.

The paper read was—

FILMS AND PAPER AS SUBSTITUTES FOR GLASS IN PHOTOGRAPHY.

By Leon Warnerke.

The use of paper for obtaining photographic negatives is by no means new. Long before glass was introduced as a support for the sensitive film of collodion or albumen, paper was known as the most convenient medium for the photographic employment of the salts of silver sensitive to light. The system most generally employed consisted in impregnating the paper with haloid salts (principally iodides). Sheets of the paper, after drying, were floated on the bath of silver nitrate, and dried again. The negative paper so prepared was not so sensitive as the wet collodion plates subsequently introduced; however, it was capable of giving results that can be favourably compared with those of newest processes of photography. Also the paper used for this process was thin, and chosen of the finest quality as regards texture. The necessity of improving the transparency of it was felt so much, that invariably it was submitted to the additional operation of waxing. This was done by impregnating the paper with wax, and taking away the excess by the aid of a hot iron. This waxing operation was performed sometimes before sensitising, sometimes after development and fixing.

The invention of the collodion process, principally in consequence of its superior sensitiveness, soon dethroned the paper process, which was so completely forgotten, that those persons who began the practical study of photography after 1850 are scarcely acquainted with the details of it.

In the year 1875, Mr. Valentine Blanchard proposed a different system of paper negatives. Through the kindness of this gentleman, I am enabled to show you a large number of these negatives. From the small original on wet collodion, an enlarged transparency was produced in the camera. From this a print was made on ordinary albumenised paper, waxed afterwards, and this was used like an ordinary negative. From the specimens in your hands you can judge of the value of this simple process. In his paper read before the Photographic Society, Mr. Blanchard says that "a paper negative is more manageable than a glass negative, and the tone given by the grain of the paper is regarded as an absolute improvement by all artists."

For more than thirty years the glass wet-collodion process was exclusively used by photographers at home, and, with some exceptions, also out of doors. The exceptions were the various collodion dry-plate processes. In these processes the burden of the outdoor photographer was lightened a little, the tent, chemicals, and laboratory required for the wet process not being necessary; but glass, with all its disadvantages, still kept its position.

Some thirteen or fourteen years ago, I conceived the idea of abandoning the use of glass, and I consequently prepared a so-called sensitive negative tissue. This was a film composed of layers of collodion and india-rubber produced on fine enamelled paper, to which it was attached during exposure and development, and easily separated after fixing and drying. The sensitive surface consisted of collodion emulsion. The collodion tissue was used either in the shape of blocks, containing one dozen sheets of the tissue enclosed between sheets of zinc, and interleaved with orange tissue paper, in order to intercept the light that can be passed through the thickness of the sheet of tissue during exposure; or in long bands, containing sometimes as many as 100 negatives, for use in the roller slide. This tissue was capable of giving a perfect result in every respect, being transparent, and devoid of any grain. The tissue negatives were superior to those on glass in all cases where blurring was apprehended. Special convenience was offered for making combination negatives, for printing in clouds, for panoramic negatives composed from several sections. I had occasion to secure a great many negatives on the collodion tissue; they remain serviceable now; and I am able to submit for your inspection some whose age at the present moment is thirteen years. The roller slide used by me was contained in a box two inches thick; by revolving the rollers, the tissue could be caused to pass from one roller to the other, and the exposure made as in an ordinary slide. In order to judge, when requisite, the quantity of tissue unwound, numbers were printed on the front surface of the tissue, and these numbers were visible through the small opening in the sliding shutter, protected by non-actinic glass.

The use of collodion tissue was not the only attempt to avoid glass in collodion time. The late Mr. Woodbury also introduced a very convenient system, partly superseding glass. In his system the outdoor photographer had to take as many glass plates as were necessary for a day's work. These glass plates were rubbed with talc, and covered with collodion emulsion in the evening, and exposure made next day. The following evening the plates were developed, fixed, and washed, and a sheet of gelatine paper soaked in water was squeegeed to the finished negative, and dried, after which the paper, with collodion film attached to it, could be peeled off from the glass, and it was immediately ready for preparation with collodion emulsion for the next day's work. Collodion negative films, temporarily transferred to the paper, were again, when convenient, re-transferred to the glass, and for that it was only necessary to take a glass plate covered with gelatine rendered insoluble by the aid of alum. The paper bearing the film was squeegeed to it under water, and left to dry; then it was immersed in tepid water, causing the melting of the soluble gelatine with which the paper was covered, while the collodion film remained permanently attached to the glass.

The history of photography teaches us unmistakeably that the sensitiveness of the negative plates is their most important quality, and that it is appreciated far more than any other consideration. The introduction of gelatine plates, superior in sensitiveness to their predecessors, rendered the collodion process a mere historical reminiscence of the past, and with it collodion tissue was put aside.

Gelatine plates are now introduced universally; but the facility of obtaining the plates commercially, and the rapidity of exposure, have only increased the number of plates used, and with that, all the inconveniences accompanying the use of the glass when away from the studio.

Efforts to get a suitable substitute for glass have not been wanting. Mr. Pumphrey, of Birmingham, advocated the use of sheets of gelatine covered with emulsion. I can show you a specimen negative supplied to me by this gentleman several years ago.

Through the kindness of Mr. Werge I can show you an apparatus devised by Mr. Pumphrey for the use of his films, called a filmograph. This is a rigid box, serving as a camera and changing box; the films to be used in this apparatus are 5 × 4. There is a focussing screen secured in position by a spring, and the same spring will help to replace the focussing glass by a box slide containing 100 films lying flat. In the top side of the camera box are two openings, protected with nonactinic glass, designed for the introduction of the light necessary for watching the operation of changing the plates. One only of the openings is used at a time, according to the position of the sun. There is a sleeve to introduce the hand, and an opening through which the interior of the box can be seen. One hand is sufficient to remove the exposed film from the front position in the box slide, and to put it at the back of all the films.

Similar gelatine films are also manufactured by Professor Stebbing, in Paris. To Messrs. Dring and Fage I am indebted for the apparatus devised by Stebbing for the use of his films. This is a roller camera of quarter plate size, it is intended for permanent focus; there is no focussing screen, but in order to judge of the position of the view of the plate, a view meter is hinged on the top of the camera. Inside the camera there are two rollers on which the film is wound. To indicate, when necessary, the quantity of the film that has been wound, there is an alarum arrangement producing an audible click.

Mr. Balagny, of Paris, prepared gelatine films on paper. The negatives taken on his paper were conspicuous at the Brussels International Photographic Exhibition, in 1883.

Mr. Thibault, of Paris, is the manufacturer of another system of substitutes for glass. In this case, there is a card sufficiently rigid to be used in the ordinary dark slide, like glass. This film is mounted on the card in such a manner that it can be developed and fixed still on the card; when dry, it is easily separated from the card, and it has a considerable thickness, so that it remains flat, and permits printing without any other support. These films are very carefully prepared, but, owing to the mode of preparation, cannot but be very expensive.

Messrs. Morgan and Kidd, and Eastman and Co., introduced negative paper, consisting of paper of the finest quality covered with gelatine emulsion. In this case the printing is done through the paper. Messrs. Eastman and Co., to avoid prolonged printing through the paper, recommend, after the drying of the negative, that it should be rendered transparent. At first boiling castor oil was recommended; subsequently, however, vaseline was found more convenient. The introduction by Messrs. Eastman and Co. of this paper (thanks to the careful preparation of the paper, and thorough understanding of the business) aroused general interest in it, and I think that it is not necessary to be endowed with the gift of prophecy to assert that the paper era, already begun, constitutes a new departure in the history of photography.

Ever since collodion emulsion was given up in consequence of its slowness, I have been working at the best system to supersede glass as a support to the gelatine emulsion film. My aim was to devise a system which should possess not only the convenience of dispensing with brittle and heavy glass, but give ultimate technical results equal to the best reached by any other process. I think my patent negative paper, introduced in 1880, fulfils this last condition. This process emanated from the principle discovered by myself, that in a gelatine emulsion film all the parts exposed to the action of light and developed with pyrogallol became insoluble in warm water.

Practically, the paper is covered with gelatine emulsion, and exposed in the camera like an ordinary plate, in an ordinary slide, or in the roller slide. Development with ordinary alkaline pyrogallol follows. After development, he paper bearing the negative image is put under water, in contact with a glass plate, and squeegeed to it; after ten or fifteen minutes it is plunged in a dish of tepid water (temperature 29° to 30° Centigrade), when it will be observed that the paper serving as a temporary support can be peeled off, all the gelatine not affected by light is dissolved, and the image only is firmly attached to the glass. From what has been said of this development, it will be seen that fixing with hyposulphite can be either used, or omitted altogether.

Now the negative thus developed has the transparent parts formed by the bare glass, and that will permit us, in case of need, to use intensification with acid silver and pyro, or iron. This is a very important means of improving the negatives, but quite inadmissible with gelatine plates, where the transparent parts formed of gelatine are instantly stained red by such treatment.

Permanganate of potash intensification, applied with such success to carbon prints, is equally well adapted here. These prints can be stained with dyes, such as aniline and others, which, when applied to the positive prints, permit us to obtain a variety of effects. I am in my paper to-night restricted to the description of substitutes for glass for negatives, consequently I shall be silent respecting the most important application of the last mentioned process to other branches of photography. To conclude the description of the process, however, I have to mention that I had occasion myself to use it extensively during my journey to Russia in 1882. I pass for examination a few negatives which have been all taken in a roller slide, which I shall describe later on.

However, perfection is always relative, depending on the requirements of the epoch, and my pet process, notwithstanding its excellent qualities, cannot be a favourite with the present photographers.

The introduction of the dry plates commercially prepared, and supplied in the form ready for use, created a very large number of adepts in an art called some time ago, very appropriately, the black art. In the olden time we had to prepare everything ourselves—and by a very complicated process—with our own hands; but that was our pleasure and delight. The more complicated were the manipulations, the more pleasure we experienced in overcoming the difficulties. Now, the requirements are quite different. New adepts are looking for the result; everything must be made ready for them, even development of the negative, that was considered in olden time as the acme of felicity, and by many as the ultimate result that only in rare and exceptional cases was followed by printing. Now it is considered a burden, often left to a subordinate. In presence of such a tendency, the extra operation with hot water and reversal of the negative, when this is necessary, are not likely to recommend themselves to the general public. Clearly understanding this, I adopted another system.

In 1884, I observed that when the paper is covered on both sides with emulsion and exposed in the camera in development, the image is produced on both sides of the paper; but if any imperfection is encountered in the paper, a counter-impression of it will be produced on the back image, neutralising the bad result.

I adapted this principle to the production of the double-coated negative paper. It is self-evident that the negative produced on such paper, being more perfect in texture, will be also superior as regards roundness and softness. This is well demonstrated by printing from two negatives.

From my own experience, and from observation of the various paper processes introduced, I believe I can arrive at a correct conclusion that, no matter how perfect is the paper destined for negative process, it must be as transparent as possible, and certainly more transparent than ordinary photographic paper. If this necessity had not been felt, the old inventor of calotype, Mr. Blanchard, and, lastly, Messrs. Eastman and Co., would not have had resort to the waxing, castor-oiling, or vaselining process, for all these oilings do not improve the texture of the paper.

Taking this as correct, it is more natural to use at once a paper that is transparent before the application of the emulsion. Such paper must be strong, to withstand all manipulation of the preparation and development. I pass, for your examination, such transparent paper, which can be prepared in lengths of 15 feet. It is so transparent that objects can be seen through it; it is textureless, and, above all, it is so elastic that, before it is prepared with gelatine emulsion, which increases its durability and strength, it bears sharp folding and bending, not showing any permanent crease.

Lastly, I pass for your examination a negative produced on this paper, and a print from it, and an enlargement (transparency) from a paper negative; this will show better than any words the absence of any grain in the negative. The time required for printing is equal to the ordinary glass negative of the same intensity.

The same views respecting the transparency of the paper are evidently taken by other inventors. The late Mr. Woodbury also perfected a transparent paper for negative. There is a hope that the last labour of this prolific inventor will not be lost, because we are informed that Mr. F. Vergara intends to work his patent, and he has kindly supplied me with specimens of the paper prepared by himself, which are here for inspection.

Messrs. Copeland and Co , of Barbican, introduced and kindly supplied me with specimens for your inspection of the so-called india-rubber film dry plates. There are also films of gelatine on transparent paper.

I know that there are many other inventors preparing, in the quiet of their laboratories, substitutes for glass according to their own ideas, and there is little doubt that the last battle for the supremacy of paper is close at hand.

The labour of the inventors to secure the victory of paper over glass was not one-sided. Their attention was not only directed to the perfection of the paper, but the construction of the apparatus was perfected in still greater measure. At this point I wish, notwithstanding the late hour, to ask you to give your special attention to the description of the apparatus kindly supplied by the makers in such variety and quantity. The majority of these apparatus are quite new, and not yet seen by anybody, and their excellence is such that they deserve most careful investigation. However, I shall be as brief as possible.

The negative paper can be used either flat, in the ordinary dark slide, or in the roller slides. Several carriers exist for the use of the paper in the ordinary dark slide. Messrs. Eastman and Co. use a rigid, flat, compound wooden board, the size of the plate, which is jammed in the light metal frame. This being no thicker than an ordinary glass plate, is used like it.

Messrs. Morgan and Kidd introduced a new frame in brass, possessing hinged flaps all round. The paper, accurately cut, is placed on the frame, the flaps are now closed, and pressed together with a book or a board; this pressure will force the centre of the paper to the level of the outside of the brass frame, while the edges, for about one one-eighth of an inch, are fastened between the frame and the flaps. All this tightens the paper like a drum.

Mr. Vergara, for the use of negative paper, introduced a special slide having the appearance of a solid double back; two card shutters are drawn right out, but there is a third card between. The paper, twice as large as the plate to be used, is doubled over that central card, and introduced in the slide, offering by this means two surfaces ready for exposure, as in the ordinary double back.

Observing that gelatine paper is so much subject to extension or contraction by changes in thermometrical or hydrometrical condition of the atmosphere, I thought that securing the paper evenly by all four sides would not give a guarantee that flatness, possibly secured at a certain moment, would invariably remain at any atmospherical change. Having that in view, I devised an "adhesive carrier," which is formed of the wooden or other board prepared with adhesive preparation, to which the paper is attached by very slight pressure, and easily removed after exposure. This adhesive preparation, a chief ingredient of which is india-rubber, does not injure the paper, while it is very durable, and not affected by temperature.

The history of the roller slides is short; we know that in 1856 Mr. Melhuish devised the first roller side, and fourteen or fifteen years ago my first roller slide was made. With the slow collodion emulsion, for registering the amount of the paper to be wound from one roller to the other, it was sufficient to have a window with orange glass, through which could be seen a number printed on the sensitive tissue at the boundary between the plates. When gelatine emulsion was introduced, orange glass became impracticable, and an electrical alarum was substituted. The band of the paper was perforated, and electrical contact being secured when the perforation came in a certain position, a bell being made to ring. The battery used on this occasion was chloride of silver with zinc; this battery worked satisfactorily without attention for two years. The spring indicator was next applied, and in its last form the roller slide before you has a measuring roller, and an indicator outside. A special punch perforates the paper after exposure, to give indication where cutting of the band of the paper is to be made.

Messrs. Eastman and Co's. roll holder is an apparatus sufficiently well known not to need separate description. It is superfluous also to point your attention to the excellent workmanlike plan upon which it has been so neatly executed. This is evident to every one.

Messrs. Morgan and Kidd's roller slide contains several original and very clever points deserving special attention. The paper for this slide is to be wound on a card tube. Besides ordinary acting rollers permanently fixed in the box, there is a third roller in wood, occupying a position between the others and parallel; this roller has a square head, so that it cannot be revolved, but it can be introduced from the outside, and fastened in position. This roller is introduced inside the card tube, bearing the supply of the negative paper, and the tube can freely revolve on it. The paper, when first introduced, is passed over the first permanent roller and measuring roller, and fastened by the aid of a slide secured in the metal tube of the second roller. To produce tension, there is a piece of wood, with springs, and lined with plush, securing this result, while the plush dusts the paper. The register secures the requisite length of the paper, while the marking of the boundary between the two plates is automatically produced by the closing of the shutter. The neatness of execution of this excellent slide equals the cleverness of its conception.

Messrs. Marion and Co. have also introduced a roller-slide of special construction. The paper for this slide is to be prepared on a wooden roller. Register is secured by the spring bell, and the tension of the paper by a spring acting on the brass plate pressing on the spool of paper.

Messrs. Shew and Co. are the inventors and makers of another roller slide. This is an improvement on my own roller slide, and a great improvement too.

The paper is to be prepared on the brass tube; the rollers of the slide are removable, but can be easily fastened in their position by a slight turn. The brass tube with the paper on it can be put over this roller, and by this means it is introduced in the slide. The measuring roller has an apparatus coupled with a spring lock, which does not permit any further revolving of the roller without a previous release of the spring. Automatic marking of the length of the paper, revolving shutter, and fine workmanship, enhance the value of this excellent roller slide.

DISCUSSION.

The CHAIRMAN, in inviting discussion on this interesting paper, remarked on the extraordinary ingenuity displayed by Mr. Warnerke, and also on the anxiety he had shown to do justice to all his competitors.

Mr. WERGE remarked that the calotype was introduced prior to the waxed paper process. It appeared that roller slides had now become as numerous as instantaneous shutters, but ingenious as many of them were, it appeared to him there was still something wanting. Instead of a gong or a click, or any other alarm, it would be better if some device were introduced such as a steel comb which would act with a spring, and actually perforate the paper through, and render it easily capable of separation, when required for developing. He was not sufficiently clever to invent such a thing himself, but if some one would take the hint, he thought it would be appreciated by everyone who worked with the paper process.

Mr. DEBENHAM said there was one point in connection with film negatives which required very special attention. The film of course ought to be stretched flat in order that the definition might be correct; and though in negatives of small angle a very slight want of flatness was not important, yet when very wide angle pictures were required, such as were occasionally necessary, say, in photographing a very high building, the very slightest irregularity of surface would be perceptible.

Mr. KIDD said the carrier introduced by him secured perfect flatness of the paper; it was stretched on all sides equally, and was in fact as flat as any glass plate.

Mr. SHEW, referring to one of the roller slides which had been described, said it was simply an improvement on the one introduced by Mr. Warnerke, and any of the American spools could be used with it.

Mr. H. TRUEMAN WOOD said he could not avoid remarking on the manner in which Mr. Warnerke had brought this matter before the Society; nobody who had listened to the paper would have imagined that all the roller slides were really modifications or improvements of his original slide. He was not the original inventor of the roller slide, but he believed he was the first to introduce a practical one into the market. He did not think Mr. Warnerke had dwelt quite sufficiently on the advantages of the paper film process. He had said nothing about the entire absence of halation secured by using paper instead of glass. He (Mr. Wood) had tried a very simple experiment, photographing first some incandescent lamps and then the electric arc itself, and the result was that although in the photograph of the arc the reverse action of light was shown very plainly, there was an utter absence of halation, which would have been impossible with a glass plate. He should be glad to hear the opinion of the Chairman whether paper could not be used advantageously instead of glass for astronomical and spectroscopic work. Gelatine plates had lately been introduced at the Greenwich Observatory instead of wet collodion, and it might be worth while considering whether a further advantage would not be secured by the use of paper; also whether the same would not apply to some extent for spectroscopic photography. He was rather inclined to doubt whether paper would ever prove an entire substitute for glass, but if so, it would be by the introduction of some such material as Mr. Warnerke had shown, which did not require oiling or even the application of vaseline.

The CHAIRMAN said Mr. Werge had made a very apposite remark with regard to the calotype process, but he should go still further, and contend that paper was used even before the daguerrotype, viz., by Wedgwood in the year 1802. The wax process of Le Gray was of course introduced afterwards. He might mention that at the same time that Mr. Blanchard was working on the method of producing negatives which had been described, he (the Chairman) was working very closely in his footsteps. When Mr. Blanchard published the process, he took it up, and produced some excellent negatives by the albumen process, some of which he exhibited in that room three or four years ago. Nothing finer could be produced in the way of enlargements. Mr. Warnerke had been very modest about his own share in the introduction of the roller slide. He believed it was in the year 1874 that he procured from him one of his roller slides for use with collodion tissue, by which he could produce 100 pictures at an outing if required. He still possessed that piece of apparatus, and he thought of presenting it to the South Kensington Museum as an historical specimen, for he did not think there were many in existence. That slide was tried for engineering work abroad, and, as far as he knew, it answered very well indeed. Of course things were changed now, and they wanted gelatine tissue instead of collodion tissue, and no doubt engineers would be able to procure them in the market for their field equipment. He had in his possession one of the very first films of gelatine produced by Mr. Warnerke. It was rather brittle, probably owing to the oxidation of the india rubber, and he thought it would be well to do away with india-rubber whereever possible, especially where it had to be exposed to the air. With regard to the bath of alum and hyposulphite, he would say, speaking from a chemical point of view, that if it were a great success it ought not to be, and he should have to make a great number of experiments with it before adopting it himself. Mr. Warnerke seemed to think that the deposit of sulphur at the bottom of the bottle was nothing; but to the chemist it showed there was some chemical action going on which did not improve the alum or the hyposulphite—probably the latter—and probably made it much less strong than it would be if the alum were omitted. He should, therefore, prefer using the two solutions separately, but of course that was a matter of opinion. It was an admirable idea to have a lock and key on a roller slide, for nothing was more mortifying than to find that an imaginative chambermaid had been looking at your dark slides. He knew a case where a person went to Ireland with the express intention of getting a large series of views, but on developing, it was found that seven out of eight were hopelessly fogged, and it was afterwards discovered to be due to the cause he had mentioned. Notwithstanding the great fuss made about roller slides, being intensely conservative in most things, he must say he preferred the old double back. If the light got in, only one piece of paper was spoiled, but if it got into a roller slide, you could not tell how many were spoiled. He used a number of sheets gummed on to a piece of card, in an ordinary carrier, and he preferred a few double backs with good paper inside to a roller slide. One great objection to the latter was that whatever little notions of art a person might have in his head would certainly be driven out of it, for the knowledge that he could take an almost unlimited number of pictures would lead him to expose a sheet on every possible occasion, and probably 99 per cent. of what he obtained would be thoroughly inartistic productions. He believed gelatine plates had been adopted at Greenwich, but not to the exclusion of the older process, and perhaps Mr. Wood would be surprised to hear that he himself had not adopted them entirely. He still had a sneaking regard for the old wet process, which he had worked for nearly twenty years, and he was not going to throw it over, because it did a great deal more than gelatine could do even yet; and he did not think gelatine ever would come up to the wet process in certain respects. Not only that, although a gelatine emulsion was very excellent in its way, there was another equally excellent, and in some respects superior, and that was the old collodion emulsion of which Mr. Warnerke used to be a great exponent. All the spectrum negatives which he had taken of the red end and the ultra-red were on collodion emulsion, gelatine would not give them. They were quite right not to adopt gelatine at Greenwich if they could not get as good results with it as with the old process. As to astronomical and spectroscopic work, for several years he had experimented on different paper processes, gelatine amongst others. He was only one amongst several spectroscopists, and they did not ignore the fact that these paper films did not give halation, and no doubt the Frauenhofer lines would show much better on paper than on glass, simply from the fact there was no halation due to the reflection from the back of the plate, which always existed to a certain extent, even if the back were blackened. There were some very much admired photographs shown by Professor Draper at the Royal Society which were sadly marred from this cause, and he ventured to remark, when he saw the negatives, that such would be the case. He feared the American savants, like the English, did not care about too minute criticism on their work, and he did not find that that criticism of his was received with the applause he expected, and therefore since then he had endeavoured to keep out of it as much as possible.

Mr. WARNERKE, in reply, said he believed the paper films would be found quite flat enough in the majority of cases. He did not mention the advantage referred to by Mr. Wood, not because he forgot it, but because he had already dealt with it more than once, and he did not wish to repeat himself. It was an advantage which was palpable to everybody.

The CHAIRMAN then proposed a vote of thanks to Mr. Warnerke, which was carried unanimously.

INDIAN SECTION.

Friday, March 19, 1886; Major-General Sir PETER S. LUMSDEN, G.C.B., in the chair.

The CHAIRMAN, in introducing Mr. Simpson, said his name and works had been before the public for the last thirty years. Mr. Simpson was enrolled in a regiment of volunteers, the "special correspondents," which might be described as a corps of irregulars, who turned upon all occasions, in all divisions of the earth, many of the members having more military experience than most general officers. Mr. Simpson first came prominently into notice in the days of the Crimea, having been with the army before Sebastopol. It was said that on one occasion this enthusiastic artist moved down, block in hand, to take a sketch of the landscape of Sebastopol and the harbour, but his movements were so suspicious, and he presented so formidable an appearance to the inhabitants, that the guns of the place were immediately opened on him. It was impossible to refer to all the wanderings of Mr. Simpson, but it might be stated that he was present at the marriage and coronation of the Emperor of Russia, he was in Paris at the time of the Commune, he witnessed the marriage of the Emperor of China, and was at Delhi during the visit of H.R.H. the Prince of Wales. He also accompanied the army during the last Afghan war, where the Chairman had met him at Jellalabad; he was then engaged in archæological research, driving a mine through the centre of a large tepé in which he expected to arrive at a treasure, and was rewarded by finding in the centre a box of ancient coins. Mr. Simpson also accompanied the Afghan Boundary Commission, and proved a very sociable companion to the Commissioners during their wanderings in Central Asia.

The paper read was—

EXPERIENCES ON THE AFGHAN FRONTIER.*

By WILLIAM SIMPSON.

The region of the Afghan frontier towards Persia and Central Asia has been, till only within the last few years, almost unknown. The unsettled state of the country made it very dangerous to travellers, and very few Europeans have ventured to pass through it. Between forty and fifty years ago, Abbott passed on his way from Herat to Khiva by the Khushk Valley, and Shakspear followed very closely after him. Abbott's account of the Khushk is very slight; Shakspear's journey I have not read. Ferrier, I think, passed Bala Murghab, going eastward, in 1845. Vambéry, on his homeward way, passed Bala Murghab, and most of his description of that place is taken up with an accident which happened, in which he tumbled into the stream from his donkey when crossing at the ford. Grodekoff passed westward at or near Bala Murghab in 1878, but his words are so vague that it is difficult to tell exactly what his route was at that point. The account of these travellers are all so very meagre that when the Afghan Boundary Commission arrived in November, 1884, it might almost be said to have begun the exploration of a new and unknown territory.

M. Lessar's survey in 1882, from Askabad to Ghurian, was on the line of the Heri Rud, and it was the most important that had taken place. It gave us a tolerably correct notion of the locality, and cleared up questions on which considerable delusion had previously existed. Up to that date it was believed that high, snowy, and impassable mountains stood between Central Asia and the main portion of Afghanistan, which it was considered it would be most difficult, if not impossible, for armies to cross; and it was supposed this range formed a strong and natural

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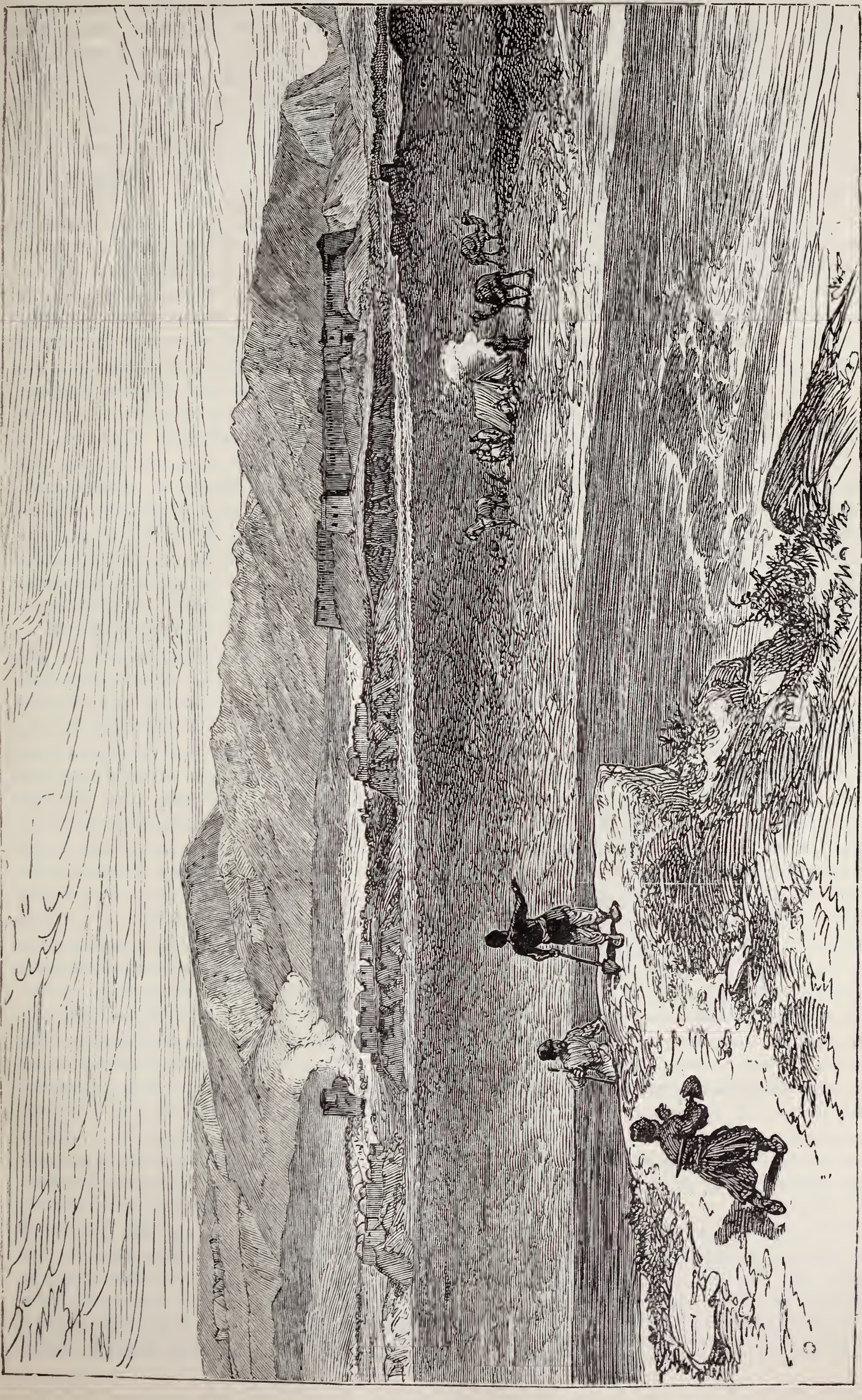
* The illustrations to this paper, taken from drawings by Mr. Simpson, have been kindly lent by the proprietors of the *Illustrated London News*.



Bala Murghab, the late Head Quarters of the British Afghan Boundary Commission.

frontier for the defence of India. Lessar found no such mountains as had been believed in, but only some undulating hills, through which a railway could be laid down without any great engineering effort. The Russians are hard at work, making or continuing that portion of the railway already made from the Caspian to Askabad, on towards Sarakhs, with a branch to Merve, which is to cross the Oxus to Bokhara and Samarkand; and they hope that the line will ultimately be connected with the Indian system of railways, *viâ* Herat and Kandahar. If this should be accomplished, it is said that the journey from London to India might be done by this route in about ten or twelve days. If we could believe that Russia had no other intentions but those of commercial enterprise in the making of this line, every one would wish them success; England, more particularly, could only hope for its speedy realisation, as she would be, as in the case of the Suez Canal, the greatest gainer from the reduction of time in the communications with India. The distance from the Caspian to the Indus may be roughly put as 1,600 miles, and Herat is not far from being a point about the middle of the line. From Sarakhs to Herat is very nearly 200 miles, and the line is being pushed on to the first of these places with all the speed which the Russian Government can bring to bear on the works.* In the future, and perhaps at no far distant time, this railway will assume a very great importance in relation to our interests in India. The Caspian Sea is all that separates it from direct connection with the railway system of Russia; and there is now a large fleet of steamers on the Caspian, so that Sarakhs will soon be in direct communication, by means of rail and steamer, with St. Petersburg. In case of war between Russia and England, it is by this railway that Russia will be able to forward her soldiers and war material towards our Indian frontier; under these circumstances this line will become prominent in connection with events. If we have peace, this railway, so far as we can see at present, will be the first line between Europe and India, a realisation which will be of the highest interest to this country.

The subject of railways in Persia, although not exactly belonging to the matter of this paper, was often forced on my mind in travelling through that country, and I think it is so important, and especially to a Society like this, that I venture to make a few passing remarks. The history of railways in Persia may be given in the words of that brief model which most people are familiar with, and would be written thus:—"There are no railways in Persia!" It may be startling to learn that this is the case, the land of the Lion and the Sun has not as yet a single mile of railway, nor up to the present moment does it seem to be contemplated to make a beginning in this direction. The Afghan Commission travelled almost due east from Tehran, *viâ* Shahrud to Meshed, a distance of about 500 miles. The natural character of the country made it clear that this has been the great highway of Central Asia from the earliest ages down to the present day. Conquest and commerce must both have passed by this route. The Elburz range of Mazandaran, which continues through Khorassan, was on our left hand, and the Great Salt Desert was on our right. It is this desert which forms the almost blank space in the centre of the maps of Persia. At some points of our journey we got glimpses of it, and the ground seemed as white from a salt encrustation as if snow had lately fallen. At particular seasons, caravans can pass through some parts of this dreadful waste, but it is done with considerable danger. As the road from Tehran to Meshed passes along the northern margin of this desert, and at the base of the mountains, it is, with the exception of only a few points, level the whole way, and the laying down of a railway would be a very simple undertaking. It might be said that the condition of the country would not justify the making of a line at present. This is, so far, true, for the whole region, more particularly the eastern portions, which have been desolated by the Turkoman raids. Caravans were as liable to attack as villagers; camels, camel-drivers, and merchandise were as acceptable spoil to the Turkomans as villagers, cattle, or sheep; and commerce suffered as heavily as agriculture. I cannot give you a better illustration of the condition of trade than by stating that there is only one post in the week between Tehran and Meshed, and that one man carries the whole weekly correspondence of this eastern portion of Persia, which includes Khorassan, in the saddle-bags of his horse. The man stopped, going and returning, at our camp, and I am inclined to think that the letters of the Afghan Commission, which included English newspapers, were most probably the heaviest part of his mail. The raiding is now a thing of the past, property, as well as person, in the future will be safe; from this a better condition of things will soon result, and a railway along this ancient highway, more particularly as it could be so cheaply made, would assist most materially towards this much-desired progress.

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* Since this was written it has been announced that the line as far as Merve is to be opened at the end of the present month, or early in April.

The extension of the Russian railway to the Caspian, with the steam communication on that sea, give Russian manufactures preponderating advantages in the north of Persia. The new railway, which has been already referred to, from the Caspian to Askabad, Sarakhs, and Merve, will give it similar advantages in Khorassan, and these advantages will not be limited to that region, nor to Central Asia, but will extend as far as Afghanistan. English goods, from want of communication, suffer already over the whole extent of that space. A small bazaar came into existence close to our camp where we wintered last year at Bala Murghab, and I noticed that all the printed goods had Russian labels on them. The shortest line to send English manufactures into northern Persia would be from the Persian Gulf to Tehran. This would not be such a simple piece of engineering as the line from Tehran to Meshed, but its importance to "British interests," in more ways than one, would be great. I do not know how far commerce and railways belong to diplomacy, but I think they ought in this case to be very prominent objects. The Shah is said to be afraid of railways, as they might be used against him in case of war. This, to our eyes, it is scarcely necessary to state, is a shortsighted policy. Railways would increase trade, and produce revenue, and thus give to his Government the sinews of war; strength, and not weakness would be the result; at the same time a mercantile alliance with England could not be a bad policy for Persia. It is said that the Shah has been saving money since he came to the throne, and I heard at Tehran that he had about 60,000,000 tomans in his coffers, or about £20,000,000 sterling. Let the Shah be made to comprehend the value of a railway from the Persian Gulf, not only to his country but to himself and his dynasty, and the means of accomplishing it, if my information is correct, is ready at hand for the work.*

But to return from this digression to the frontier, the supposition of a high and impassable mountain range is not the only delusion which exists regarding this region. There is another mistake which is more extensively accepted, and the Press has helped largely to give it publicity. This is, that the ground along the line of the Afghan frontier is a desert. Some of our journals expressed themselves that the few miles of sandy waste about which the diplomatic correspondence lately took place was not worth disputing about. The region is undoubtedly a desert now, and has been so for a long time back; but it will be my object to show you that it was not always so, and that it need not remain in that condition. The point is one of great importance, as it will show the probable future which is yet in store, not only for the country along the frontier, but also for nearly the whole of Central Asia. If it is incapable of improvement, and must remain more or less a desert, its political importance will of consequence be at all times comparatively small; but if it is possible to produce fertility, a state in which everything can be grown in the greatest abundance, and consequently a large population must come into existence, it will appear evident that time is only required to evolve very great changes and influences, which must affect its position and relations with the surrounding countries.

There is nothing new in the information I am about to lay before you. The few men who have made a study of Central Asia are well acquainted with its former condition; but I propose to give you my own experiences, and describe what I saw, the details of which are so far fresh, a character they owe to the circumstance that we have had so few travellers in that part of the world.

I shall begin with Sarakhs, as that was the first place of importance which we touched on the frontier. With the permission of General Komaroff, I visited the arg of this old city. This is a square-shaped mound; I can only speak

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* A paper was read at the Royal Geographical Society, on January 15th, 1883 (and a report of it will be found in the proceedings of that Society for March of the same year), by Colonel Champain, R.E., "On the Various Means of Communication Between Central Persia and the Sea." This paper, with the remarks made upon it, when it was read, by Sir Frederick Goldsmid, Colonel C. E. Stewart, and Mr. G. S. Mackenzie, will show the importance of this subject to British interests. The suggestions made at that time referred principally to the improvement of roads, and for opening up the Karùn River, near the head of the Persian Gulf, for the navigation of steamers. The three years which have passed since that paper was read have changed the whole aspect of the case. This is owing to the Central Asian Railway; and a railway only can give the conditions necessary to compete with the position as it now exists.

MERUCHAK, ON THE MURGHAB RIVER.

vaguely of its size, as I have no measurements, but it might be about 150 yards on each of its sides. Burnes describes it as a "hillock." Sarakhs is on the eastern bank of the Heri Rud, about two miles from the river; it stands on the south-western corner of the great plain of Central Asia, which was at some previous period the bed of a sea, either an extension of the Caspian, or when the Caspian and the Black Sea were one continuous sheet of water, and formed part of the Mediterranean. The horizon, extending from the north-west to the east, presents a line as straight as if it were the ocean; this line is only broken by mounds marking the spots where towns or villages have stood in former times. The arg of Sarakhs seems to be a heap of earth; parts of a very ruined brick wall, with towers, still exists along its upper crest; within this the ground is covered with bricks and fragments of pottery; nothing remains of the buildings but a crumbling ruin towards the western side. What was the size of the town which surrounded this citadel my hasty visit gave me no chance of forming even a guess. I could see on the plain a few walls of what had once been mud houses of a late period;* and the few people at present dwelling there—they are of the Salor Turkoman tribe—were in round huts made of reeds, of the most primitive description. Houses in Persia at the present day are built of mud, or of sun-dried bricks, which is only mud in another form; this seems to have been the principal building material in this part of the world from the earliest times; and it only leaves mounds for ruins. Although this is rather tantalising to the archæologist, a careful inspection of the ground at Sarakhs would no doubt result in a rough estimate of the space which had formerly been covered with houses. The only structure left on the plain is on the south of the arg, it is a tomb which is said to be that of Abel; on the west of New Sarakhs, which stands on the left bank of the Heri Rud, is another known as the tomb of Cain. This is a burnt-brick building, very beautifully ornamented with stucco, in which texts from the Koran are a prominent feature. These tombs are in ruins and deserted; they no doubt owe their legendary character to the story that Adam had his garden at Sarakhs, and came up every morning from Serendib, or Ceylon, to work in it. This tradition may be taken as at least indicating that a very high antiquity has been ascribed to Sarakhs, which has been a place of note for a long time back. It stands on the principal road from Persia to Merve, which is also the road to Bokhara, and far Cathay, and the trade passing through must have made it a place of wealth. I have described to you all that is now to be seen of what in the past has been an important city. It has all but ceased to exist. The population have been exterminated, and their habitations have disappeared. In this you have an epitome of what has taken place all over the region. Robbery and destruction have reigned supreme, and desolation has been the result.

This state of things has been produced by the raiding of the Turkomans; a system which has gone on more or less for ages. Bands of these tribes collected together, and were called "Alamans," sometimes in small, sometimes in large numbers, under the command of some chief who had earned a reputation for success in such forays, preyed upon the countries round, and carried off horses, cattle, and sheep, as well as men, women, and children, where-ever they could be pounced upon; these last were borne across the desert of Central Asia to the bazaars of Khiva and Bokhara, where they were sold into slavery. It is this raiding system which produced the ruin, and the desert condition of the Afghan as well as the Persian frontier, over which we passed.*

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* Burnes mentions that there were "a few mud houses, which have been built by the Jews of Meshid," who, he says, trade with the Turcomans. That was in 1832. Only the fragments of walls now remain.

* It is difficult to say when this raiding system began; Genghiz Khan has been suggested as the originator, and he may be looked upon as one of the greatest of the raiders; but the system is older than him. When Ovid was in banishment at Tomi, a place near the mouth of the Danube, he wrote the books now known as "The Tristia," or Lamentations, describing his hard fate in being an exile among the uncivilised Segthians and Getœ, and he gives a description of them, which agrees in every detail with the doings of the Turkoman of our own days. He says, that when "Mighty Boreas congeals the waters of the sea, or those flowing in the river, the Danube being made level by the drying northern blasts, the barbarous enemy is carried over on his swift steed: an enemy, strong in horses, and in the arrow that flies afar, depopulates the neighbouring region far and wide. Some take to flight, and no one being left to protect the fields, the unguarded property becomes a prey; such as cattle, and the creaking waggons, the little treasures of the country, and the riches besides that the poor inhabitant possesses; some are driven along as captives, with their arms fastened behind their backs, looking back in vain upon their fields and their homes; some die in torments, pierced by barbed arrows, for on the winged steel there is a poison, in which it has been dipped. What they cannot carry with themselves, or lead away, they destroy, and the flames of the enemy consume the unoffending cottages; even when there is peace, they cause alarm from the apprehension of war, and no one ploughs the ground with the pressed ploughshare." The "winged steel" was supplanted in later times by a gun, slung on the back; that is the only point in which the acoount requires an alteration.

The supply of water which irrigated the ground at Sarakhs was carried by a canal which starts from the Heri Rud, about ten miles to the south; it still exists, and I think I heard some one say that the canal extended north-wards over a space of about fifty miles, that large space being irrigated by its means. There are other canals, one of which leads the water to the west side of the river. It was by these that a sure supply of water could be relied upon for the fertilising of the land, and by these means a large extent of ground was cultivated.

Pul-i-Khatun is, roughly speaking, about forty miles south of Sarakhs; and about ten miles to the north of the first named of these places, the remains of an old town are visible. This is on the left bank of the Heri Rud, for there is some level ground on that side, while on the other there are cliffs, and low undulating hills, forming part of the lower slopes of the Koh-i-Baba range. This old town is known as Shir Tepé, tepé being the word for a mound; the one at this place being also square in plan like Sarakhs, but much smaller. On seeing the mound at Sarakhs, it struck me that it might have grown by an accumulation resulting from the repeated building of mud houses, such as I have seen in villages on the plains of India, where the village, from rebuilding, through a long course of time had produced a small hill underneath it; but this theory had to be given up when I saw Shir Tepé, for as the ground had been long deserted and undisturbed, the mounds which marked the remains of the town could be seen around the tepé, but they formed only a slight elevation above the original soil. According to the cumulative theory, which had suggested itself to my mind at Sarakhs, the town would have risen up as well as the tepé, but here, and it was equally marked in other places which I saw, the tepé stood high above the mounds of the town. I mention this because these mounds of this part of the world are almost a new subject to us, and I have seen theories suggested about them such as that they are ancient mound tombs, or the high places on which, in the Zoroastrian times, the fire altars stood. In later times they were undoubtedly forts or citadels, the walls and towers at Old Sarakhs, as well as in others which I saw, may be cited to illustrate this; the other theories may be more attractive than this simple one, but it seems sufficient to account for them. It is supposed that some of them are very old, which is most probable, but at the present day it is almost impossible to judge of their age, for mounds present no features such as we find in architecture to indicate the period of their construction. Abbott mentions a mound at Merve, called the "Kullah Ghubbah," or fort of the Guebres, which is supposed to be as old as the time of the Fire Worshippers; and yet we know that the Turkomans have, at the same place, erected a very large fort, formed of mounds, since the fall of Geok Tepé in 1881. O'Donovan was in Merve in that year, and describes the making of this, and speaks of its great size. This instance is sufficient in itself to show how uncertain must be the age of these remains.

Pul-i-Khatun, or the Lady's Bridge, is so named from being built by a daughter of Taimour; it is well constructed with burnt brick, it has seven arches, and is 175 feet long. The central arch was destroyed about sixty years ago by Medhly Khan, when retreating after a reverse, otherwise the bridge would be still serviceable. Near to its western end is the ruin of a large caravanserai, this, with the bridge, tell us that formerly there had been a considerable commercial traffic passing at this place; probably two routes at least went past here, one from Herat and India towards the Caspian, and the other from Meshed to Sarakhs and Merve. About a week or ten days before our arrival at Pul-i-Khatun, the Russians had advanced a piquet of about forty or fifty men from Sarakhs, who were living in hastily-made reed huts, otherwise the place was a solitude. This deserted condition exists westward along the valley of the Keshef Rud, which joins the Heri Rud at Pul-i-Khatun, to near Meshed, a distance of about 100 miles.

From Pul-i-Khatun south along the Heri Rud, to the junction with the Jam Rud, which may be put roughly at about fifty miles, is a region of hills. The continuation of the Koh-i-Baba range, which continues westward into Persia, and forms the Elburz range, this again runs west till it joins the range of the Causcusus. This magnificent ridge of mountains begins in the south-east near the mouths of the Brahmaputra, and terminates at Anapa, near to the Straits of Kertch. It contains the highest mountains in the world, and that portion of it that passes through Central Asia used to be called by the Arab authors "The Rocky Girdle of the World." The only break in the whole extent of this great mountain chain is where the Heri Rud finds its way northward to the Central Asian desert. This is comparatively a very small stream, to which the Rocky Girdle seems to bow low, and make a way for it to pass. This is where the great mountain range, snowy and impassable, was supposed to exist which has been already alluded to. Our route south was on the western bank of the river, and among the undulating hills as we went along, wherever there was any extent of flat ground, we were certain to see mounds, with fragments of pottery on the surface, telling of former habitations. The entrance to the Zulfikar Pass is about thirty miles to the south of Pul-i-Khatun. There is a fine bold cliff which sweeps round from the mouth of the pass to the river, which bears, in its character and outline, a striking resemblance to Salisbury crags at Edinburgh. Opposite this, on the Persian side, is the wide Zurabad plain, stretching in a north-west direction towards Meshed. This, as far as we could see—like the ground we were travelling over—was a wilderness; not a house or a human being was to be seen. We crossed the Stoi range of hills, which brought us down on the valley of the Jam Rud, and from that the ground is an undulating plain all the way to Herat. On the Afghan side the hills tend away to the south-east, increasing in height as they go. On the Persian side the Jam Valley opens out on the south into a plain, bounded on the west by the Khaff range. This great plain has been the basin of a large lake, perhaps extending for nearly a hundred miles in some of its dimensions; and through the middle of this basin the Heri Rud now flows.* The outlet of this would be at a gorge called the Tengri Daria, where the passage is so difficult, that we had to cross the Stoi range on the west to avoid it. This plain is no exception to the general character of the region; it is also a wilderness. Towards the western edge of it, and along the Jam Rud, the walls of ruined villages are still standing, but on the eastern side the mounds only of villages can be seen. Its former condition may be estimated by a descriptive title which yet remains; it is still known as "the district of the 350 ruined villages." This plain is, I believe, only an extension of the Herat valley, whose wonderful fertility had in the past covered the whole of this wide space. The condition of the mounds of these villages is such as to imply that it is many years since the population disappeared.

About twenty miles north from Kuhsan, on the west bank of the river, is an old caravanserai, built, as an inscription on it states, in the year of the Hejra, 838, by Toman Agha, a queen of the house of Taimour, about the same date as the construction of the Pul-i-Khatun bridge. The caravanserai is, or rather has been, a very fine one, and although deserted, it tells us that commerce and travellers were passing through this region in former times, where all is now so desolate.*

It was at Kuhsan where we joined the camp and that part of the Commission which had come from India. The town is the first inhabited place as you go south to Herat, from which it is distant about sixty miles. To the south of it villages are scarce; so far as I remember, none were visible in that direction. But I believe the ground is cultivated to a large extent, the cultivation increasing towards Herat. It was arranged here that the heavy portion of the camp should move eastward, by the direct line, while Sir Peter Lumsden, with a slight escort, and a portion of the Survey Department, started towards the north-east to visit Penjdeh.

From Kuhsan we crossed the plain and made for Chasmah Subz, or Green Spring Pass, where we crossed the Koh-i-Baba range as it descends away to the north-west. On my return in February I crossed this range by the Robat-i-Surkh Pass, which is but a little to the north-west of the other. A short distance on the western side of the pass there is a caravanserai of red brick, which gives the name to the place. As there is no caravanserai at the Chasmah Subz Pass, I take it that the Robat-i-Surkh Pass was that generally used as the main road in former times between Meshed and Afghan Turkestan, through which the important road led by Maimuna to Balkh. Neither of these passes are difficult, as the range is of no great height; but in the winter they are liable at times to snow storms, as our Commission has had some rather severe experience, even as late as the end of March.

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* Mr. Finn, of the Consular service, who has lived at Turbat-i-Shaik Jam, which is in the valley here described, quite agrees with this supposition of a lake having existed. He tells me of a curious tradition in confirmation of it. About sixteen miles higher up the Jam River is a place called Langar. Now this word means "anchor," and the legend is that it got its name from Noah having anchored his ark there after the waters retired.

* The Heri Rud was the ancient Arius, and the district between Herat and Meshed, which is that here described, is defined by Professor H. Wilson, "Ariana Antiqua," p. 150, as the ancient Aria. This region must be distinguished from the larger region of Ariana.

After crossing the Shasmah Subz Pass, we had the Koh-i-Baba range, rising in height away to the south-east on our right, while before us, as far as we could see, were low undulating hills forming the northern slope of the Koh-i-Baba, and which extend north to where they finally dip down into the Central Asian plain. This country is the ancient Badghis, a name which Colonel Yule has shown existed as early as the 6th or 7th century. As we passed along we found the remains of villages in the valleys, and the evidences of former cultivation; the most of the streams are salt, but at their sources some of them are fresh; this is the case at Gulran. The remains of *kanauts*, or underground canals, were visible at some places. The higher portions of the ground, it struck me, could never have been cultivated, at least this was the conclusion I had formed one morning as I was riding over them; but the decision was scarcely arrived at when I found my horse putting his feet into a hollow which turned out to be the remains of an old irrigation channel; where it brought the water from I could not tell, no doubt from some point higher up in the hills; but this slight hollow proved to me that the most of the ground, valley as well as upland, had been at one time under cultivation. Now the wild boar turns up the soil for bulbs and roots, and often we saw a cloud of dust left by the *goorkhur*, or the wild ass, while flocks of gazelles wander undisturbed. The Jamshidi shepherds are the only human beings occasionally to be seen; we passed a couple of them with large flocks of sheep, in which black and brown are the predominating colours of wool. These flocks were in themselves clear evidence that there was no danger now from raiding Turkomans.

We struck the Khushk Valley at Kara Tapah, which means "Black Mound"—I give the names here as they are on the map, and as I heard the places called, but tapah is the same word as tepé. In most parts of the world where there are hills or high ground, advantage has been taken of them upon which to build places of defence; but in this particular locality at least, heights seem to have been carefully avoided. All the way from Sarakhs to Bala Murghab in no case did we find these tapahs placed on elevated ground, and, with the exception of Sarakhs, there were hills or positions of eminence which might have been chosen. The mounds seem to have been purposely raised on the ground which was cultivated. I have no doubt but there had been a reason for this very marked peculiarity; but what that reason was I cannot pretend to say. The Khushk valley at Kara Tapah may be about half-a-mile of level ground in width, and the great dark mound stands about the middle of it. It may be about 40 or 50 feet in height, and I think it had been at one time originally square; there were walls and towers of brick all round; these were in ruins, but in better condition than those at Sarakhs. Here, as in other cases, I take it that the walls were much more modern than the mound; there were no buildings within the ruined walls; round its base were a few walls of mud houses. The fields and watercourses indicated that there had been cultivation carried on at no very distant date. I understood that about a century ago there was a large population at Kara Tapah. The Khushk, at the time of our visit, the end of November, was a very small stream of clear water, only a few yards wide.

Our course from this was northward, which is down the stream, to Chaman-i-Bed. Before reaching that place, we came upon a few of the Saryk Turkomans that had moved up from Penjdeh, and they were busy ploughing, and clearing out the old watercourses, so as to bring the land again into cultivation. Before coming to Chaman-i-Bed, there is a mound called Kara Tapah Khoord, or the "Little Black Mound." This was very nearly square, being about 120 by 100 yards. On the north-west corner there was a higher elevation, the summit of which might be a square of about 22 yards. There were no walls on any part of this mound, and it was very regular in form, and level on the top, so much so that it looked as if it had been a gigantic lawn-tennis ground. It must have been centuries since any structure has existed on this tapah. To the south of it are some slight undulations marking where a town had stood.

The next march, in which we passed Hauz-i-Khan, brought us to Kala-i-Maur. The water of the Khushk disappeared on the way, and reappeared again at Kala-i-Maur. The hills on the west side of the valley at this place sink down to almost a plain, and here the mounds of the old town are scattered about. In the middle is a large flat mound, and here again there stands the ruins of an old fort built of large square bricks. This mound is now so irregular in form, that I could not speak with certainty as to its original form, but if it had at first a regular shape, which I am inclined to suppose was the case, the probability is that it was square and not round. As the lines of the ruined fort have no reference to the form of the mound, and it is much smaller—it is about 60 yards square, while the mound is about 150 yards—it confirmed the conclusion I had come to in relation to the other tapahs, that the forts were all of later construction.

We were told that there had been at one time a hundred karerizes, or underground water channels, at this place; I certainly noticed the remains of one. These were no doubt for irrigating the ground on the west side of the Khushk, which was, although low, too high to be watered by the river. The shapeless mounds, filled with fragments of pottery in very large quantities, showed that the town had been one of importance. The number of burned bricks, yellow in colour, and about a foot square, scattered about, became an additional evidence. There were two or three dimensions of bricks, and they varied slightly in colour; as these had been used very indiscriminately in building the fort, I am inclined to think that the bricks had not been made for it, but were the remains of older structures. Some of the Saryk Turkomans told Sir Peter Lumsden that this was the old city of Bukshoor, or "Sher-i-Bukshoor," and that it had been the capital of the district in the time of "Sultan Senjir Mosé." The statement of a Saryk Turkoman is not very authoritative in archæology, so I only give this as I heard it. The name, Kala-i-Maur, means the Fort of Merve. The whole district was known as Maur, Mawer, or Merve; and Sanjir, I think, had Merve—the place at present known by that name—as his capital; and Kala-i-Maur may have been a departmental capital; or it may have been some chief who had made himself at some time independent, and assumed the important name to indicate his claim to the whole district.

About 28 miles farther down is the junction of the Khushk and the Murghab. There is an old brick bridge, Pul-i-Khisti—*khisti* meaning "Brick;" this was the scene of the action which took place between the Afghans and Russians. The bridge has nine arches, and is similar to the other old bridges of the region: although marked by the influence of time, it is still capable of use. In late times it has served the purpose of an aqueduct, to carry the water of a large irrigation channel across, and from this it has been supposed by some to have been erected at first for this purpose.

About a mile to the east of the bridge, but still on the west side of the Murghab, stands Ak Tapah, or the "White Mound." The first glimpse I got of this mound was about five miles away; the sun chanced to shine, and it had a strange appearance, gleaming out with grey whitish light, which at once explains its name. Here, again, there are hills forming the valley of the Murghab, and a slight plateau, whose spurs project close to the mound, but these advantages of height are ignored, and the tapah has been raised on the very lowest of the level ground. This has led me to suspect the possibility of some early religious significance between these heaps and the cultivation of the fields. Ak Tapah is the largest of all the mounds I chanced to see; in plan it is more a triangle than a square, about 300 yards in its greatest length, and about 150 yards across; the height being about 100 feet. If this was a fortress, a character which I doubt not it possessed, its object was evidently that of guarding the junction of the two important valleys which meet at this place, and this importance may be the explanation of its great size, which in the time of its erection we may suppose implied strength. The ground round Ak Tapah is filled with fragments of pottery, showing the existence of a large town at some former period.

Penjdeh is six miles higher up the Murghab, and almost all the way from Ak Tapah there are mounds, the earth of which is mixed with fragments of pottery. Kona Penjdeh, or old Penjdeh, is on the left bank of the river; there is no great mound, which is very exceptional in this part of the world, but the site is still well defined by ridges left by its mud walls. On the other side of the river there are mud walls still standing. In the hills on that side, Captain de Laesoe has discovered a very curious group, about twenty, of caves excavated in the sandstone rock; there are other caves in the region, which, so far as we yet know, may be ascribed to the Buddhist period, and are interesting as showing that Buddhism had extended thus far to the north-west. I mention these only as indications of the former condition of prosperity which existed, for a poor and small population were not likely to trouble themselves cutting out chambers in the rock. Captain de Laesoe describes remains on the right bank of the Murghab extending for about five miles, and the width varies from one to two miles.

We found the Saryk Turkomans scattered along the valley, from about two miles south of Ak Tapah to Meruchak, a distance of about twenty miles. They live in kibitkas; many of them have only reed huts formed in the shape of kibitkas. These Turkomans seem as yet to have no idea of constructing more substantial dwellings.

Meruchak (see p. 482) is about 20 miles further south, and it has, at some former time, been a large town. There is one of these peculiar mounds here. It is about 90 feet high, and the space on the top is about 80 yards by 70. The remains of a wall which may be as old as the mound, and almost as high, extends from it to the north-east in a circular form; on the outside of this there is a more modern mud wall, enclosing a space square in form, and perhaps about a quarter of a mile on each side. In comparison to the great circular wall, this outer one is of much smaller pretensions, and it is now in a very tumble-down condition. There are a few mud walls standing within, but almost all the space is quite bare and empty. There are mounds overgrown with scrub extending for a considerable distance on the outside of the walls. These undulations are extensive, and I could not judge very well, owing to the vegetation, as to their limit. We may suppose that here, as well as in other places I have spoken of, that many towns have succeeded each other, but it is impossible by merely looking at such mounds, and with no opportunity of excavating, even to venture on a guess as to relative dates. It must also be remembered that mud, or sun-dried bricks, only leave shapeless mounds, no ornament, or vestige of even a moulding, is left to guide the explorer. In the name Meruchak we have again the word *meru* or *merve; chak* has been supposed by some to mean small, and that the whole word may be put as the Lesser Merve.

The Saryk *kibitkas* end at Meruchak, and there being no danger from Turkoman raids, the Jamshidis have come down the Murghab to near Karaoul Khaneh, occupying the ground again and bringing it under cultivation; but there is yet a space of more than twelve miles which is still in a condition of jungle. Here our party had some good sport, for the pheasants have been undisturbed for a long time back, and were in such plenty that it was declared that no preserve in England was equal to it. At Karaoul Khaneh, which is on the right bank of the Murghab, there are remains of a town, but only mounds; they are very small in comparison to Meruchak or Penjdeh. Bala Murghab is ten miles farther up the river; there are some mounds on the way. At Bala Murghab the Afghans have constructed a fort on what seems to have been an old square mound; and there are indications of mud buildings having existed in many spots round, but here again the remains fall far short of Meruchak and Penjdeh. The foundations of the piers of a bridge can be traced at Bala Murghab; somewhat similar remains of another, I was told, exist about four or five miles further down; and I ought to have mentioned another, of which only the piers remain, at Meruchak.

At Bala Murghab (see p. 479) the Commission settled down for the winter.

I have given these details of remains, as there is considerable archæological interest attaching to them; but my principal object in this case has been to convey some idea of the large number of towns and villages which formerly existed, and by this means to indicate the large population which found subsistence in the region. Land itself is of small value in Central Asia; it is water which gives value to the soil. The rivers, by means of irrigation, were used to fertilise the ground; and there are both large and small rivers which have been utilised for this purpose. Wherever the waters of these streams could be led by canals a plentiful harvest might be relied on, for the solar heat there is not an uncertainty, such as we have lately found at home here. The two celebrated cities of Bokhara and Samarkand have derived their subsistence from a river called the Zarafshan, which, from the fruitfulness it produced on the soil, was called "The Gold Scatterer." It is the water of the Oxus which fertilises the soil of Khiva. Balkh, known as "The Mother of Cities," and which as late as the 7th century was between three and four miles in circumference, stands on a considerable river flowing from the Paropamisus, called the Balkh or Dehas River. Merve, which was celebrated as "The Queen of the World," depended wholly upon the water of the Murghab. There was a large dam in ancient times to the south of Merve, and from it many canals existed, which led the water over the ground in the form of a delta, and thus irrigated a large space. Maasoom, the Emir of Bokhara, destroyed this dam in 1784, whatever then remained of the importance of Merve was destroyed at that time. Firdusi calls the Murghab the "Shahd Rud," or the Honey River; the Bundahis calls it the "Marv River," and declares it to be "a glorious river in the East." The deserted character of the country between the Heri Rud and the Murghab, and the barrenness resulting from the absence of trees or foliage of any kind, I have described; this is the district known as Badghis, the Bundahis calls it "Vadges," and says that it is a "quarter," full of timber and full of trees." * The same book mentions a mountain, which must have been somewhere in the same region, for it was this mountain that "Frâsiyâ of Tur used as a stronghold, and he made his residence within it; and in the days of Yim a myriad towns and cities were erected on its pleasant and prosperous territory." Afrasiab, the great Turanian hero, as well as Yim, are very mythical personages, although we may be doubtful of the wonderful things recorded of them personally, we may suppose that the "myriad towns and cities," as well as the "pleasant and prosperous territory," are statements which may be accepted. These references give the reputation which Central Asia had in the far past; but at a later period we have the authority of the Arab authors, who describe it as the richest country in the world; and the means by which this richness was produced they seem to have perfectly understood, for they applied to the rivers the term of "Blessed."

These "gold-scattering" and "blessed" streams still exist. They flow down from the hills as they did before, and have only to be again utilised as they were in the times gone by.

Even at our own time I can find an evidence of a very strong kind. Herat has suffered from wars and sieges, as well as from the general demoralisation which has blighted all that part of the globe, but it has existed all through its many vicissitudes, and remained an inhabited place. Suffering in the past, it has to the present day retained its celebrity for fruitfulness. Colonel Malleson has written a history of Herat, and on the title page he has added to the name the words—"The Granary and Garden of Central Asia." Such an expressive sentence requires no comment. The valley of Herat, that has this wonderful reputation, is comparatively of limited extent. Colonel Stewart, in a paper lately read before the Royal Geographical Society, gives it as about 120 miles. The fertility of this small space is derived from the water of the Heri Rud, which flows through it; but this river runs on to Sarakhs, and beyond that again into the desert; the distance from Herat to Sarakhs is 200 miles, and with the exception of about 50 miles, the space between Pul-i-Khatun and the juntion of the Jam river, the land might be all as productive as the Herat Valley. This illustration will convey in itself some notion of the future that is in store for Central Asia. To the space capable of cultivation on the Heri Rud you must add the Valley of the Murghab, which from Bala Murghab to Merve is very nearly another 200 miles. Along every stream that flows north from the Koh-i-Baba, as far east as Badakshan, there is ground to be fertilised. From Sarakhs again, in the other direction, all the way to the Caspian, where numerous streams run from the hill country of Khorassan into the plain, there are mounds, the remains of old towns, and witnesses of former fertility. From the Caspian to Badakshan on the east is a space of at least 800 miles, at present more or less a desert, the result of war and rapine, but more particularly of the raiding system of the Turkomans—a system which has at last come to a termination after centuries of bloodshed and misery. The people must turn to the cultivation of the ground, and from the description I have given some estimate may now be formed of the probable result of such a changed condition of things.

This result may be put in the form of a common arithmetical problem—If the few miles which are cultivated at Herat give that place so much political importance, what will a country of watered valleys, extending over 800 miles, produce?

The north-eastern part of Persia, which includes Khorassan and Mazanderan, also suffered from the raids. On our march eastward to Meshed and the Heri Rud, we had scarcely reached a hundred miles from Tehren, when we came upon evidences that the raids extended to that distance westward, which will be about 500 miles within Turkish territory. The Turkomans carried off everything, horses, cattle, and sheep; the men, women, and children were taken to Khiva and Bokhara, and sold into slavery. The cultivation of the ground and the rearing of animals was carried on under dreadful risks. Commerce also suffered, from the danger to the caravans, and at the same time from the poverty of the country, caused by the raids. I have already described the postal wants of this part of Persia, which may be taken as a pretty safe indication of the commercial condition. Persia seems to have been powerless, or indifferent, while this raiding was going on, and which existed till only about three years ago. Russia can now claim the great honour of finally and completely suppressing the whole system.

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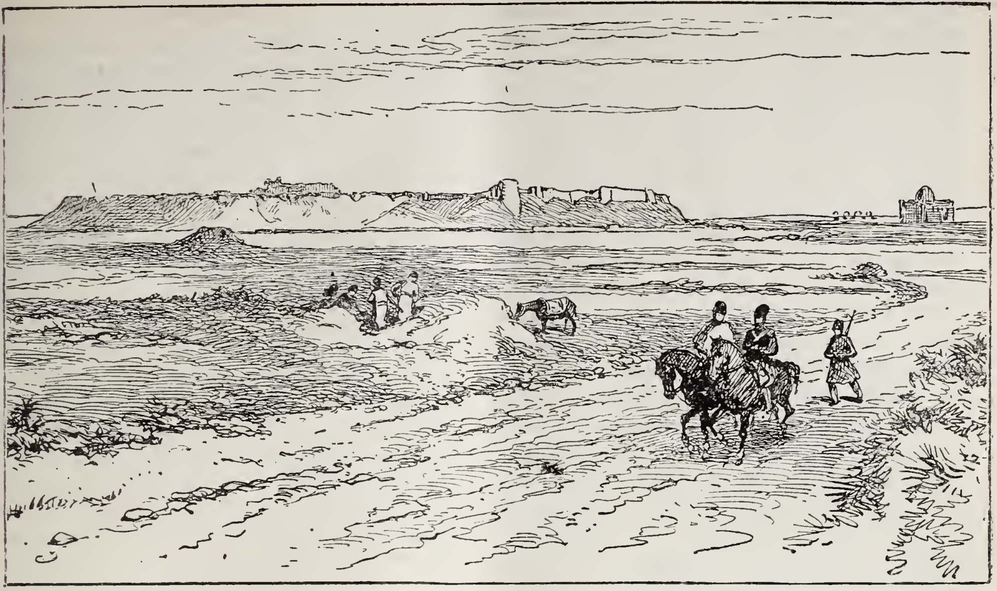
* "Sacred Books of the East," vol. v., p. 38.

With the conquest of Geok Tepé, and the occupation of Merve, the abominable system came to an end. In this accomplishment Russia is entitled to the gratitude of all civilised nations. There is still work for her to do on the new ground she has occupied. It is a desert, but as I have described it to you, it is, much of it at least, capable of cultivation; to bring this back again to its former fertility, by means of irrigation, and thus restore population and commerce, would be a task worthy of a great nation, and I feel sure that Russia will do this. To make Central Asia again "the richest country in the world," which the Arab authors declare it to have been in the past, might be a more profitable occupation for the Russian Government to take up seriously than to make the region only a new field for the doubtful manipulations of diplomacy.

In passing over a region such as I have described, in which the only remains of the past are mounds of earth, I need scarcely say that I saw nothing, or almost nothing, which related to the former condition of art and architecture. I believe that mud, or sun-dried bricks, was the principal material used in building. Mosques and palaces may have been constructed of burnt bricks—we saw bricks in some places, varying in size from about 8 inches to 12 inches square; important buildings had their walls faced with glazed tiles, and often these were painted with ornaments. Sun-dried bricks in that climate forms a good house, and with an outer skin of glazed tile, it may be made highly ornamental. At Meshed we were encamped for a day or so in a garden which had a very large gateway, in ruins, and it was in this style, although in a rather a poor kind of art, still it was effective. At Mazinan, an old Persian place, where there still exists more than one town in ruins, and all of mud, I entered a room which had been beautifully finished inside with stucco; the ornament was simple and good, some of it almost as fine as the composition ornaments on our picture frames of the present day. At Sarakhs there is a tomb, a very large one, built of burnt brick; it is said to be the tomb of Cain, which has already been mentioned. The front of it was covered with stucco ornament, the whole of which was exceedingly well done. It was the best bit of art I met with in that part of the world. Almost all the mounds inspected were covered with great quantities of small fragments of pottery with a high glaze, and very beautiful tints, in which green, blue, and yellow predominated. At Herat there are buildings with glazed tiles, and the art of making them has ceased to be practised. At Lahore there is a very fine Musjid, as well as tombs, and the remains of an old gateway, decorated with glazed tiles. There also, I was told years ago, that the production of these was a lost art. Central Asia was probably the original home of this art; it was brought into India by the Mohammedans, and specimens still exist about old Delhi. I have seen the gold domes of St. Petersburg and Moscow, but the domes of blue glazed tile, which are still visible among the ruins of Lahore and Delhi, are far more to my taste; and I may here express the wish that the art which produced them might again be cultivated. An effort at such a revival would be an object worthy of the attention of our Indian Government. I see no reason why such an art might not be transplanted to England, where we have seen the lamentable results of attempts at gilding external portions of buildings, as well as the failure of one or two experiments of painting in colour. Glazed tiles would be impervious to London soot, smoke, and rain. When the dome of St. Paul's has to be again erected, I hope that the art of producing glazed tiles will be so well known and appreciated, that there will be a lovely blue dome to look at from all points, instead of the black, funereal-looking mass we have at present.

The only chance we had of seeing anything of the Turkomans was between Penjdeh and Meruchak, where the Saryks had their huts. These people produce carpets, and have little more than one design, which they seem to go on repeating. It is a very poor one, but the quality of the work, owing, I believe, to the fineness of the wool, is, in some of their carpets, most remarkable. The introduction of modern colours from the West, it is to be regretted, neither improves the character of the design nor the quality of the carpets. Various articles connected with the Turkoman *kibitkas* —the peculiar moveable huts or tents of these nomadic races—are made of the same material as the carpets. The doors are simply a piece of carpet hung up like a curtain; long strips of the same are made to hang round the inside of the *kibitka*, and large bags of it are suspended from the walls to serve the purpose of clothes chests.

In the small bazaar that grew near our winter camp at Bala Murghab, pieces of silk as well as silk dresses were for sale. I often asked where the silk came from, and the



Old Sarakhs.

answer was always "Bokhara." The supposition suggested itself that this place had a reputation for this article of manufacture, and that it might perhaps be the Lyons of Central Asia. As a rule the colours in the designs are rather loud, some of them remarkably so. There is one style of pattern which is peculiar to this Bokhara silk, and which I should say is distinctive, in which purple, pink, and yellow are curiously blended.

The silver ornaments of the Turkoman women struck me as belonging to a peculiar style of art; we were told they did not wear gold ornaments in that part of Central Asia. Judging from what I saw, a woman, if she had the means, must wear a large quantity

New Sarakhs.—The Mashed Gate.

of silver on her person. I have seen elaborate headgear, large earrings, necklaces, ornamental placques for the back, as well as for the front, massive and heavy relic-holders to hang on the breast, and ponderous bracelets, which were put on, at least so we were told, in childhood—and which from their make, could not, without the intervention of the silversmith, be removed again. I have seen no art similar to what is to be found on these ornaments. Persian art and architecture had penetrated into Central Asia, but this was not Persian art. The pattern on Bokhara silk, which I have just mentioned as distinctive, had forms on it closely allied to those on the silver ornaments. The impression produced on my mind is, that this distinctive art is the remains of what had been at some period a style peculiar to Central Asia, and that in all probability Bokhara, or the region around it, had been the headquarters of its cultivation. I put this guess with all diffidence, for I have not had the chance of seeing enough of it to speak with certainty. Could I have extended my experiences as far as Bokhara and Samarkand, a wider knowledge might have been acquired. The leading forms on the silver ornaments are, I suspect, Chinese in character, or, what is still more probable, they may be Mongol. These forms are generally bordered with a fine, and often very minute, filagree work, which may perhaps be Mongol also; but it calls to remembrance the very delicate work of a similar type of the Greeks, and I put it as a guess merely, that this style originated from a combination of the old Bactrian art, brought there by the Greeks (we now know that Greek art and artists, as early as a century or so before our era began, were in that part of the world), with the art of the Turanian races, who overturned the Greeks and supplanted them, not only in Central Asia, but as far south as the Indus.

In conclusion, I ought to allude to one great work which the Afghan Boundary Commission is carrying out, that is, the making of a survey of the region, and the production of correct maps. The best of our maps were found to be far from accurate; some places were as much as 12 and 13 miles out of their true position. The survey department are officers of the Royal Engineers—Captains Gore, Peacocke, and Talbot, the head officer being Major Holdich—all men of great experience in the work; and in future we shall at least have reliable maps of this hitherto but little known part of the earth's surface.

DISCUSSION.

Colonel STEWART said, having had the pleasure of being with the Chairman and Mr. Simpson during a portion of their journey through Central Asia, he might, perhaps, be permitted to make a few observations with regard to the mounds to which reference had been made. These mounds, which in ancient times were used as fortresses, were not originally built for that purpose, but were raised as the base for fire temples. He had seen one of these mounds with a fire temple on the top of it which had been in use in very recent times. There were now very few fire worshippers left in Persia, but some of the few that remained had restored one of the fire temples near Ispahan, which he had had an opportunity of inspecting. He regretted to say that the beautiful carpets which were at one time made by the natives of Merve were a thing of the past, those now made, since the Russians took possession of Merve, being of very inferior quality. Aniline dyes had been introduced into the country, and the carpets were now decidedly inferior.

Mr. TRELAWNEY SAUNDERS thought that justice had not been done to the early geographers; for instance, Aaron Arrowsmith, whose great map of Asia shows the country between Heri Rud and Murghab. This map embraced all the information which could be gathered at the time, and it was stimulated to a great degree by the labours of men like Kinnear, Fraser, and others. There was another map of later date, and of much more complete character, made by an officer whose name would never be forgotten by Englishmen in connection with Herat, viz., Eldred Pottinger. They also owed a great deal to General Ferrier, and to Mr. Seymour, who translated Ferrier's Travels, and appended a map prepared by John Walker; but the map which came nearer home was that prepared by himself for Vambéry's travels in Central Asia Until the trained surveyors of the Government of India came upon the ground, nothing had disturbed the claim of this map to precedence. He did not agree with the statement that the route taken by Grodekoff was unknown, for a Russian map had been published showing the route taken by this traveller after passing the Oxus. Well informed persons did not believe in the impossibility of armies crossing the mountains between the Heri Rud and Murghab, or anywhere along that range. The late Lieutenant Sturt surveyed a route for artillery between Cabul and Balkh. When speaking of the origin of the destruction of the countries alluded to, he thought they must not forget that this was mainly due to that terrible scourge of humanity, Ghenghiz Khan, who blotted out many great cities.

Mr. MARTIN WOOD said he was glad that so eminent a geographer as Mr. Trelawney Saunders had remarked on the rather scant justice rendered, in the opening passages of the paper, to the explorers and route-makers of two generations ago.

That journey of Abbott to Khiva was, for instance, was a wonderful achievement in those days; and his review of the vast countries he traversed, considering the scanty appliances of those days, compared with the scientific implements of the present time—and no one could estimate that difference better than could the chairman of the evening—was, as Mr. Saunders had testified, of great value. Many must remember that it was so long since as 1863 or 1864 that Mr. Simpson's fine pictures of the Eastern Himalaya were on exhibition in London, and which were afterwards reproduced to embellish a splendid volume, the letterpress of which was written, he believed, by the late Sir J. W. Kaye. But, reverting to the subject of the evening, he (Mr. Wood) felt it was not easy to say much upon the general question raised by the paper as to how the country could be restored. Mr. Simpson seemed to have great hopes that the valleys might be made to smile again, and be thickly populated, but the question was, how was this to be done? It was said that water was still there, but he should like to know whether there was anything like the volume which at one time existed? The restoration of forests would replenish the streams, and population would then increase. This was a natural process, and one which could be relied on, but it was a matter for generations. After all, they must feel that the most specially interesting portion of the paper was that in which Mr. Simpson, as an artist, had incidentally spoken of the fine effect of the glazed tiles of Central Asia and Khorassan. But he seemed to be too hopeful in thinking that this old world decorative pottery could be reproduced here. If introduced, it would come under the remorseless hand of our steam machinery, and then that charm that attracted Mr. Simpson and other artists would vanish away.

Mr. SIMPSON was sorry if he had done injustice to the earlier geographers, but his paper was not meant to cover the works of all these authorities. He had merely referred to the books of some of the authors, and had no idea of ignoring the labours of others. The supply of water had nothing to do with the destruction of forests in Central Asia, for the water of the Heri Rud came from the melted snow of the Koh-i-Baba. No doubt the question of bringing back the population was one of time.

The CHAIRMAN said that, after the very interesting paper to which they had listened, there was but little left for him to say. The construction of the Russian Central Asian Railway was a matter of the utmost importance. They had every reason to accept the estimate as to the progress of the work originally given by General Annenkoff, who predicted that he would carry the line to Merve by the spring of this year, and to the banks of the Oxus by the close of it. They had no particular information as to the estimate for the work, but originally the distance was calculated as about 759 versts from the Caspian to the Oxus, and the cost 16,000 roubles a verst, making a total cost of about 12,240,000 roubles. If the actual cost was kept within this estimate, it would be one of the cheapest railways in the world. The line crossed over a plain, and consequently but few bridges would be required, except perhaps where the line crossed the valley of the Tejend. Whatever might have been the routes of commerce in former days through Central Asia, the simple iron rail would obliterate the past, and the sands of the desert would entirely wipe them away. The railway would be the road of the future, by which trade, traffic, and travelling would be carried on through Central Asia. Were there no transit duties on that portion of the country to the south of the Caucasus, a very great trade would spring up between Central Asia and Europe; and some years ago, during the period that the Grand Duke Michael was in charge of those provinces, and no dues were demanded upon trade, the people at Asterabad assured him the trade in a few years increased some 50 or 100 per cent. Owing to the pressure put upon the Russian Government by the merchants of Moscow, large import duties had again been placed upon all goods going to Batoum, and the trade was now rapidly decreasing. Although, as stated by Mr. Simpson, there was no great commerce in the north of Persia, there was a certain amount of cotton which went by way of Shahrud, the trade being entirely in the hands of Armenian agents. Not many years ago, fine silk was produced in Mazanderan and in the northern districts of Persia bordering the Caspian, but owing to disease among the worms, this trade had entirely disappeared. Whatever was now produced, even to the fish from the sea, on the banks, or in the Caspian, went into the hands of Russian traders. The only articles of real value in that part of Persia were assafœtida and opium. The Russians had, perhaps, done more than any other people in carrying out the repopulating of new countries. They had a system throughout all cantonments by which the soldiers who took their discharge had opportunities with their families of remaining in perpetuity on the land, and becoming a part of the population of the country, this tended to amalgamate the Russians with the people of the country. With regard to Merve and the extension of cultivation, the Governor-General of the Caucasus had informed him that the programme of the Russians was to reclaim the four great oases of that part of the world, viz., the oasis of Tehjund, the oasis of Sarakhs, the oasis of Merve, and the oasis of Penjdeh; they had taken the work in hand, and certainly were progressing with it as quickly as any people could do. Up to the present they had projected two lines of canals from above Yulatan to south of Merve, one running in a north-east and the other north-west direction. There was already a considerable area on the banks of the Murghab, extensively irrigated by canals, and the object of these two new canals was to extend the surface of cultivation. The work towards the north-west was the reopening of an old canal, and during the last year the Russians had cut thirty if not sixty miles of it; it would eventually reach as far as the line of railway towards Merve, and would not only irrigate the land in its vicinity, but would create a population along the route. Mr. Simpson had referred rather doubtfully to the authority of Moolah Abdul Mohmin, who stated that in the valley of the Khushk Kali-i-Maur was formerly known as Bukshore; and all he could say was that if the Moolah was wrong, so was the highest authority in this country, Sir Henry Rawlinson, who held the same view. In conclusion, he proposed a hearty vote of thanks to Mr. Simpson for his interesting paper.

The resolution passed unanimously.

SIXTEENTH ORDINARY MEETING.

Wednesday, March 24, 1886; Sir FREDERICK ABEL, D.C.L., C.B., F.R.S., chairman of Council, in the chair.

The following candidates were proposed for election as members of the Society:—

Audsley, G. A., Devon Nook, Duke's-avenue, Chiswick.
Bromhead, Horatio K., 245, St. Vincent-st., Glasgow.
Cracknell, John Edmund, Glan-y-mor, Havergal-villas, Green-lanes, Wood-green, N.
Crocker, Frederick Joel, 147, Cannon street, E.C.
Darke, Edward Thomas, 16, Rochester-terrace, Camden-road, N.W.
Grote, Arthur, 42, Ovington-square, S.W.
Hobson, Richard, The Marford, Bramborough, Cheshire.

The following candidates were balloted for and duly elected members of the Society:—

Aitkin, Charles Edmund, M.R.C.S., 7, Clifton-place, Sussex-square, W.
Breen, George, 204, St. Vincent-street, Glasgow.
Burdett-Coutts, William, M.P., 1, Stratton-st., W.
Stein, Cecil, 42, Ladbroke-square, W.
Symons, Henry, J.P., Totnes, Devon.

The paper read was—

DOMESTIC ELECTRIC LIGHTING.

By W. H. PREECE, F.R.S.,
Vice-President of the Society.

Electric lighting, on some distributive plan like that of gas, is still an event of the future in England. Other countries (notably the United States), Germany, Austria, Italy, Belgium, &c., are ahead of us, but in the electrical illumination of our houses—the traditional castle of the Englishman—we are in advance of all other countries. The number of private residences now lighted by electricity is very considerable. The way in which men of wealth have constituted themselves into amateur electricians is very characteristic of this country. There is something about electricity, in all its practical applications, that renders it captivating. Its marvels excite the imagination, its powers astonish the mind, its ready adaptability encourages invention, and its easy control favours its employment for many purposes where mechanical appliances would, in many cases, be more suitable. Hence men of means and of leisure have made its study a hobby. There is no purpose to which wealth can be applied more beneficial or praiseworthy than that of aiding the thrashing out of problems whose successful results lead to the greater comfort and happiness of the many. Pure air in our lungs means health in our bodies and energy in our minds. The success of domestic electric lighting is a great sanitary question, and its solution has a much greater significance than mere commercial rewards. Municipal authorities expend fabulous sums in preventing the contamination of our water, but no local power has yet attempted to remove the poison from the air we necessarily breathe with our present mode of artificial illumination. Electric lighting does not do this, but it stops the supply of the vitiating gases.

Now, the progress of electric lighting in this country has been very seriously checked by the inordinate mania for speculation that characterised the year 1882, and the terrible losses that ensued therefrom; but there has been a quiet, steady progress made, that has not been checked by restrictive Acts of Parliament, and has not been deterred by misapplied capital.

I want to chronicle what has been done, and how it has been done. The pioneers of domestic electric lighting in England have been Sir William Thomson, Sir William Armstrong, Mr. Coope, Mr. Sellon, and Mr. Charles Moseley. Sir William Thomson used a gas engine, and worked his lamps direct from the dynamo, not only lighting his house, but his class-room and laboratory in the University of Glasgow; Sir William Armstrong obtained his power from a waterfall in his grounds; Mr. Coope used a steam engine; and Mr. Sellon and Mr. Moseley relied on secondary batteries, obtaining their power from a gas engine. Their good example has been very largely followed, and there are now a great many private houses in all parts of the country thoroughly and efficiently lighted. In fact, electric lighting is becoming a fashion, and the only fear for its ultimate general success is its falling into the hands of the inexperienced and ignorant—one chief cause of its check in the past. I have not known a single case of failure where the installation has been undertaken by experienced men. There have been many disappointments where

> "Fools rush in where angels fear to tread."

Electric lighting means the utilisation for illuminating purposes of a certain amount of energy, which has to pass through various stages and forms, from its dormant condition in coal and water to its active condition in a lamp. I propose to discuss the question in each stage.

THE MOTOR.

Steam, gas, and water have been used as agents for the production of power, but petroleum has not yet had a trial in England, and wind is too uncertain to be relied upon. Water is the most economical when it has not to be paid for, gas the most convenient, but steam is the most reliable.

Electric lighting by incandescence absorbs much power. Power is the rate of doing work or of expending energy. Mechanical engineers measure this rate of doing work by referring to an arbitrary and erroneous standard called the horse-power; but electricians have introduced a new standard, more scientific and exact, called the *watt*. The watt is the work done in one second by an ampère flowing through an ohm, and having, therefore, an electric pressure of one volt. The number of ampères multiplied by the number of volts gives the number of watts. A watt is equal to ·7373 foot pounds per second, and there are 746 watts in one horse-power. I am in hopes that the present horse-power will become a thing of the past, and that all engineers will measure power in watts, on the decimal system. A kilo-watt is not a euphonious name, but it is a truer and more scientific term than horse-power. An engine giving off 10 horse-power developes therefrom 7,460 watts.

Now, an average glow lamp, well incandesced, gives one candle-power light for each, three watts expended in it, and, therefore, a 20 candle-power lamp absorbs 60 watts, and a 10 candle-power lamp 30 watts. Hence 10 horse-power, if all utilised in the lamps, will maintain 124 20 candle-power lamps, or 248 10 candle-power lamps in full incandescence. Thus, if we know the watts to be expended in the lamps, it is very easy to calculate the power required to maintain them alight. It is customary to allow eight 60 watt or sixteen 30 watt lamps per horse-power, so as to give a fair margin for loss in conversion and transmission.

A simple effective safe domestic steam motor has yet to be introduced. Hathorn, Davey, and Co., of Leeds, exhibited at the Inventions Exhibition the best that has yet been made, but it has the disadvantage of requiring a large supply of water to condense the steam. It is a vacuum-engine working at atmospheric pressure, and is, therefore, free from explosion. The various high-speed engines that have recently been introduced by Peter Brotherhood, Willans and Robinson, Fielding and Platt, Beauchamp Towers, &c., require higher technical skill than is usually to be found among the domestics of an ordinary household, and the difficulty of comprehending, examining, and repairing them stands in the way of their use. A simple single or double acting steam-engine of small horse-power, that shall be economical in working and not liable to break down, easy of repair, that shall work with great regularity of speed, and be easily governed, and that does not require a skilled engineer to attend to it, is a great desideratum. The Council of the Society of Arts have under consideration a plan, so eminently successful in the agricultural world, and pursued for many years by the Royal Agricultural Society, of offering prizes for the best engines designed to fill the special purpose of providing power for electric lighting purposes. The points of merit that are considered to be of the greatest importance are—

a. Regulation of speed.

b. Power of automatically varying speed to suit variation of load.

c. Noiselessness.

d. Cheapness.

The competition is intended to embrace all classes of engines—steam, gas, petroleum, &c.

The gas-engine seems best adapted to supply this want. Gas is already in use in most establishments within reach of gas works, and it seems far more natural to utilise the energy stored up in gas to generate power than to poison the atmosphere we breathe, deteriorate our valuables, and dirty our walls by burning it in air for illuminating purposes, especially as we get more light by doing so. Twenty-five cubic feet of gas will give us 1 horse-power, or eight 20 candle-power glow lamps, or 160 candle-power in all; but five 5-feet burners will give only 75 candles when burnt in air in ordinary burners. Gas-engines are within the intelligence of butlers, gardeners, and coachmen; they are always ready for work; they attain their maximum efficiency at once; they can be stopped in a moment. They are not noiseless, though they are advertised to be so, and they are rather wayward. Some of them develop tempers of their own, and they occasionally cause angry expressions, but their efficiency is remarkable; and in spite of an oppressive monopoly nearly as bad as that of the telephone, they are rapidly coming into favour, and when the present patent expires, they will doubtless receive very great improvement, and much greater development.

In England, the opportunities of using water-power are few and far between. Small powers are easily obtained, but from 10 to 15 horse power requires a considerable quantity of water, or a higher fall than is usually attainable in any but hilly countries. The power of the tide, or that of a flowing river, is very small when utilised within the limits of ordinary people. The whole flow of the Thames through London-bridge would maintain only 800 lamps alight.

In Scotland, however, the case is different. There several persons have utilised the water stored up in lakes. Sir John Fowler has lighted his Highland home by using three turbines of 12 horse-power, which, night and day, work dynamos. A 5-inch pipe from an artificial lake gives a head of 310 feet.

Mary wonder why the wind is never used, but, apart from its uncertainty and unreliability, there is the fact that the power developed by the best windmills is, on the average, but very small. They are so unreliable that the proprietors of most windmills keep a steam-engine as a stand-by. The windmills so largely used in America and Holland for irrigation purposes exert but the fraction of a horse-power, and it requires a very wide expanse of sails to obtain, even in high winds, sufficient power to light a country house.

The Dynamo.

The relief which the practical world receives from the removal of the burden of a monopoly is well illustrated by the advances made in dynamos. The expiry of the Gramme patent was the signal for energy everywhere. Not only has the construction of the instrument been vastly improved mechanically, but its output has been trebled, and its price reduced to one-third; so that the dynamos of to-day are nine times better than they were during the existence of the patent. We are chiefly indebted to Elwell and Parker, of Wolverhampton, for leading the way. Hefner Alteneck first struck out a new path, which was taken up by Edison, and indeed has been well-nigh perfected by the high scientific attainments of Dr. J. Hopkinson, and has been ably followed by Mr .Crompton. Science has converted a crude instrument into the most perfect converter of energy that exists. Commercial enterprise has brought it within the reach of all. I have for the past two years been converting 2 horse-power into electrical energy with an Elwell-Parker dynamo that cost £30.

The improvements that have been effected are due chiefly to the more intimate knowledge that experience and study have given us of the theory of the machine. Better shaped magnets, more intense fields, more accurate proportion of parts, better copper and better iron, improved ventilation, have trebled the energy given out by each pound of copper wound on the armature. The intensity of the field has been increased five times; machines are far less troublesome; faults have become less frequent; armatures do not burst up so often; sparking at the brushes is less evident; commutators do not cut so much; heating of the coils is a thing of the past; and the ill effects of self-induction are being eliminated. The forms of dynamos are being whittled down to two or three recognised shapes; but as long as the spirit of rivalry is stirred up by competition and emulation, so long shall we have some manufacturer who will make a change for the sake of a change, and who will advertise his wares as the best in the world. Suffice it to say, that for us users little remains to be desired in the quality and price of the dynamos. The output may be increased and the speed may be reduced, but we cannot gild refined gold nor paint the lily.

The efficiency of a dynamo is the ratio of the energy given out in the external circuit to the energy supplied by the engine, and this in most modern dynamos exceeds 80 per cent. The out-put of a dynamo is measured by the number of watts it delivers, and this becomes a very convenient measure and indication of its capacity. Dynamos are now indicated in kilowatts (or "units," as some call them), and when we are told that such and such a dynamo is a 12-unit or a 12-kilowatt dynamo, we know it can deliver—

120 ampères at 100 volts, or
150 ampères at 80 volts, or
200 ampères at 60 volts,

according to its requirements. This also enables us at once to determine the horse-power required to drive the dynamo. 12-kilowatts means 16 horse-power, add one-fourth to allow for loss and waste, and we get 20 horse-power. Dynamos usually indicate the E.M.F. they work at when driven at a certain speed, and they have, or ought to have, the proper number of revolutions per minute engraved or painted upon them. If makers would only supply with their dynamos their characteristic diagrams we should have all the information the user wants.

Dynamos are classified into *shunt*, *series*, or *compound* wound, according to the work they have to do. The former are almost exclusively used for domestic purposes, for reasons which will presently appear. A well-constructed dynamo, kept clean and well lubricated, never overworked, should last a lifetime without much attention except to the brushes and commutator.

BATTERIES.

No isolated installation is complete without a secondary battery. It maintains regularity and uniformity of current, so as to secure absolutely steady light; it supplies a reserve of power that renders one free from accident to engine or dynamo; it supplies a store of electricity that provides the householder with a source of light at all times and seasons. If you wake in the middle of the night, there is your light; if you have to start by an early train, and dress before daylight, by a mere pressure of a button you have your electric lamp alight; if you have to breakfast on a dark, foggy, murky morning, you feed in soft daylight. The secondary battery has been much before the world. Its early failures disappointed many; it was launched before the public at too early a stage of its infancy. It has sown its wild oats, but it is now a matured, sober, practical instrument. Sir William Thomson says:—

> "My cells have worked to perfection. It is the greatest possible comfort to us in the house to have the light with satisfactorily equal brilliancy, at all hours of night and day, and every day in the week. I have now cut off the gas at the meter, so that there is absolutely none used in the house. I have no oil lamps, and have not used so much as a single quarter of a candle within the last three months, and have the electric light in every part of the house where light can possibly be wanted by night or by day."

I can confirm every word of this. I have now had nearly two years' experience of them, and I would just as soon dispense with them as I would with my fireplaces or bedclothes.

Originally I used them as a regulator to my gas-engine, but I speedily found that it was more convenient and economical to charge them during the day, and discharge them through the lamps at night. In the depth of winter I charge them every day; in late autumn and early spring three times a week; and in summer I charge only once a week. It is very easy to know when the cells are fully charged. When the charging current is put on, the E.M.F. commences at about 2 volts per cell, and gradually rises to about 2·5 per cell. It acquires its maximum only when the cells are full. The current, on the contrary, falls. The density of the liquid, which is observed by a hydrometer floating in a cell, gradually rises, and when it becomes constant, the cell is full. Several hydrometers are used. Gas is then freely given off, and the cell has a milky appearance.

On the other hand, when a cell discharges the hydrometer sinks, and when it reaches a minimum point it must be charged again. The E.M.F. also commences to fall when it is too empty, but I never allow that point to be reached. Good cells give an efficiency of 70 per cent. without losing E.M.F., and with a loss of 10 per cent. they will give over 80 per cent. The useful rate of a battery is the number of ampére-hours it will give before losing 10 per cent. of its E.M.F. It is quite possible to get out of a battery all, or nearly all, the energy that we put in, but we cannot do so at a useful or economical rate. I give in the Appendix a record of the charge and the discharge in my house in the month of February last, and also as record of last week's work.

The durability of these cells is most satisfactory. I see no reason why they should not last ten years at least. In fact, I believe the makers will maintain them at the rate of 10 per cent. per annum.

The faults that I have experienced are very few and rare. Short circuiting from peeling or buckling are things of the past. I have never seen a case of "treeing." Occasionally the connections develop resistance, and get hot, but this is solely due to neglect; they require attention and cleanliness.

It sometimes happens on high days or holidays that more current is wanted than can advisably be drawn from the cells; the engine is then allowed to run as well, but if the current developed by the dynamo is in excess of that used in the house, a few cells have to be taken off the battery, which is readily done by a switch, in order to maintain the E.M.F. in the house at its normal point. It is impossible, in fact, in the house to tell whether the engine is going or not. If it happens that the engine is kept continuously running, while the batteries are in action, special steps have then to be taken to prevent the cells from being irregularly charged, by changing the idle cells periodically.

A secondary battery acts perfectly as a regulator as long as it is well charged; its resistance is so small compared with the lamp circuit that it may be regarded as nothing, but if from any bad contact, fault, or weak cells, the resistance becomes appreciable, fluctuation in the light becomes evident, and it ceases to act efficiently.

The latest form of cells are exhibited on the table, and they are now so well-known that they need no description in this paper.*

PRIMARY BATTERIES.

I have had no practical experience of their employment for domestic lighting, nor have I seen a house lighted up by them; but I believe there are several installations at work, and I am sure the Society will be glad to hear in the discussion some facts from those present.

LAMPS.

No great progress can be chronicled in lamps like that in dynamos and secondary batteries. Their price remains very high. The ridiculous practice of giving lamps a fictitious nominal candle-power, which reached such a height of absurdity in arc lamps, and which was partially adopted with glow lamps, has nearly died out. Lamps which were called 20-candle lamps are now sold as 16. The nomenclature of lamps is very illusory. The same lamp can be used to give 5, 10, 15, or 20 candles, according to the number of watts expended in it. A good standard glow lamp has not yet been devised. I should like to see a 10-candle lamp working under a pressure of 50 volts, and requiring half an ampère. that would mean the absorption of 25 watts, or 2½ watts per candle. Its life would not be very great at present, but if it were cheap enough, one would not mind frequent renewals. Since secondary cells are inseparable from isolated lighting, low E.M.F. means fewer cells, and therefore smaller capital expenditure, and small current means slow discharge. Ten-candle lamps are ample for domestic illumination; they lend themselves to better distribution of light. Two 10-candle lamps will give better illumination than one 20-candle lamp. My ideal lamp has not yet been placed in the market, though there are several approaches to it.

There is great variety of practice in determining the number of volts best adapted to work an installation. The conditions that regulate a central station system are quite different from those regulating domestic lighting. The former requires high pressure to reduce the weight of the mains, the latter requires low pressure to reduce the number of cells. Both are governed by economical reasons. The Edison Swan Company adopt 100 volts; Sir William Thomson uses 85 volts; the Anglo American Brush recommend 65 volts; the Electrical Power Storage Company, 60 volts; I recommend 50 volts for home lighting. I tried originally 31 volts, but I had to increase the pressure, for the low volt lamps took too much current from my cells.

Makers of lamps seem to consider that there is great credit in securing long life. Unfortunately, glow lamps deteriorate sadly with age. The carbon wastes imperceptibly away, and we are scarcely conscious of the fact that, after 200 or 300 hours, the lamp gives only half the light it did at first. The fact is lamps last too long. I have been relegating my old lamps to the bedrooms, but they will not die, and I have been obliged to remove them "ere their time." The price of a lamp should be such that we could afford to give them a short and merry life. Long life is therefore an objection.

The efficiency of a lamp is generally taken to be the number of watts it consumes per candle per 1,000 hours of life; but a good measure of efficiency would be the number of hours it took to lose 10 per cent. of its normal light when absorbing 2½ watts per candle.

Some interesting experiments were recently made in Berlin on this point by Mr. Wilhelm Siemens, who showed that in 800 hours an unflashed carbon, consuming 5 watts per candle, lost 37·7 per cent. of its light, falling from 19·9 candles to 11; while a flashed carbon, consuming 3·2 watts per candle, lost only 12·7 per cent., falling from 17·5 candles to 14·5.

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* Until January of this year I had been using Elwell-Parker cells at my house, but I am now trying the E.P.S. form, having removed the former to the Post-office.

The resistance of the former increased 12·7 per cent., of the latter only 4·2 per cent. The process of flashing carbon is a process by which pure hard grey carbon is deposited upon the carbon filament by heat, decomposing some hydrocarbon gas with which the globe is filled. This deposit of carbon enables the filament to acquire a brighter surface, and attain a higher temperature before commencing to disintegrate, and therefore it gives a higher efficiency, for the amount of light given out depends simply upon the temperature.

A glow lamp, when incandesced, seems to lose its carbon mass steadily and regularly. The carbon molecules fly off, and are projected against the sides of the globe where, they adhere, and cloud or discolour the glass; so that the light is diminished in two ways—first, by the wasting of the carbon, and, secondly, by its being deposited upon the glass, and preventing its radiation. The resistance increases owing to the diminution of the sectional area. This goes on until eventually, at some weak point, the mechanical strength is reduced to such a point that the filament becomes too weak to bear the slight strain upon it, and it breaks; or the density of the current becomes too high, and it dissipates away like a bright star, leaving a gap across the filament. This weak spot can often be detected by its brilliance before the lamp goes.

There is a critical point in all lamps when a change of state occurs in the carbon filament. It is shown by the appearance of a beautiful blue effect pervading the whole globe. It occurs at some point between 1 and 2 watts per candle. It should be determined for each kind of lamp.

I have an example of a lamp destroyed by lightning in Mr. Elwell's house, near Wolverhampton, which shows very beautifully the destructive effect on carbon of very high E.M.F. The globe is converted into a beautiful mirror.

Lamps fail in giving their light occasionally from having an imperfect vacuum. This is very easily detected by feeling the globe. If the vacuum is bad it gets quite hot. Mr. J. T. Bottomley showed that a wire became red hot when the air was exhausted from the globe, though it was only 80° C. when the air was in. Occasionally, but very rarely, lamps explode with a loud report when the current is first put on. This is, perhaps, due to a slight leakage of air making an explosive mixture with the residual gas.

At the present moment, both the nomenclature and the efficiency of glow lamps are in a very unsatisfactory state, and we are buying pigs in a poke at a very high price.

Mr. Edison adopted the very meritorious plan of determining the E.M.F. which would give his lamps a life of 1,000 hours, and the current that would give it the normal light. If this were done by every maker, it would be easy to determine the life at any other E.M.F., or the light at any other current, for the former varies with the twenty-fifth power of the E.M.F., and the latter with the sixth power of the current.

Considerable difference of opinion exists as to the character of the globe enveloping the carbon filament. Some like them clear, some like them ground; others envelope them in shades—generating light simply to choke it; while others, at a great loss, make the globe of a beautiful opal glass. It is very objectionable to have the optic nerve irritated by a brilliant glowing filament; but it is equally absurd to produce a good thing and then strangle it. Grounding and shading mean loss of light. Lamps can be placed so high that they need not affect the eye, and if they do, the light can be so reflected as to be useful elsewhere. The art of lighting a room is to flood it with light without the delicate eye being offended with the direct rays from the source of light.

An essential feature of a good lamp is a good holder, by which lamps can be readily removed and renewed. The platinum loops, which Mr. Swan originally introduced, proved very troublesome, through constant breakage. Edison's screw-holder was a much better, though more expensive thing; but Mr. Alfred Swan has recently introduced a "vitrite" holder which embraces the merits of each, and leaves little to be desired.

Switches to turn the lamps on and off are a source of great trouble in a house. As a rule, they are cheap and nasty. When fixed away from the lamps, they introduce into the circuit additional resistance, and therefore waste energy, but they are distinctly serviceable when they are fixed outside the door of a room, so that you can light it before you enter it.

In many cases the lamp itself is its own switch, but it is objectionable to handle a lamp, and attempts have been made to utilise the weight of the lamp itself when suspended from the ceiling to maintain contact, and to break that contact when the weight is released.

Cuts-out or safety-valves are essential to the security of a house. Short circuiting ought not to occur, but it does, and generally when showing off. It may occur when cleaning. The cut out is so cheap and so effective that there is no excuse for its neglect. They should be fixed on every circuit.

FITTINGS.

The comfort and pleasure of a house depends upon its fittings. It is here that taste has its sway and art its swing, and the two are regulated only by the balance at the bank. It, however, fortunately happens that electric lighting does not lend itself to expensive fittings. The simpler they are the more effective. Sir David Salomons, who has spared no expense in obtaining energy at Broomhill, has exercised wise economy and rare taste in fixing his lamps. They are so suspended by their own conductors that in daylight you do not see them, but when darkness comes, they spring into light like beautiful stars floating in the air. No one has taught us so much in this direction as Mr. Tayler-Smith, whose portable lamps and useful appliances were so much admired at the Healtheries, and at the Inventions last year. My house is full of them. I have lamps everywhere, and I can get light wherever and whenever I want it.

WIRING.

No one must imagine that electric lighting is absolutely safe from fire. It certainly possesses elements of danger, but elements that are perfectly under control. Several cases of fire have taken place, but invariably from crass ignorance. It is very simple to secure safety if the rules and regulations to avoid fire risks be carefully followed. The simplest rule is to use nothing but the best insulated wire, and to employ none but experienced men to put it up. All accidents that have occurred have arisen from careless wiring and ignorant handling. Wire has been ordered by so-called electrical engineers of such a quality that manufacturers have absolutely declined to supply it. Competition is so active, owing to the depression of business, that prices have been cut down so low that work can only be done at a profit by the use of poor stuff.

In a new and growing business like electric lighting, competition should be very guardedly resorted to. There are firms of repute who are experts, and who can be trusted to carry out everything, but they are few. Protection should be procured by careful specification and constant supervision. The electrical engineer is as essential to the success of the building as the architect, and he should be engaged professionally. There is a great deal too much work done by the tradesman alone, and too little left to the expert. The design of the circuits of a house, the dimensions of conductors, the quality of the materials used, the provision against fire risks, the testing of the work done, the adaptability of means to an end, should come within the province of the professional adviser, and not be left to the successful competing contractor, however eminent the firm may be.

METERS.

It is very desirable in a well-equipped house to see at a glance how many lamps are burning, how the dynamo is behaving itself, how much current is going per hour into the battery, how much is coming out, and how well the electric pressure of the battery is maintained. Hence it is essential to have as good a voltmeter to measure the electric pressure in our circuits as we have a barometer to measure atmospheric pressure, or a thermometer to measure temperature or heat pressure. The most efficient, reliable, and simple that I know is Cardew's. Again, we must have a good current meter, and though ampère-meters are thick as autumnal leaves in Vallombrosa, they are, as a rule, uncertain and misleading, especially with fluctuating currents. Siemens's electro-dynamometer remains master of the situation.

Ferranti's meter is a most admirable adjunct. In my house one measures the current going into the batteries, and another measures the current coming out, so that I am able to keep an accurate debtor and creditor account against my battery. The result for February is seen in the appendix. How far these meters are accurate within a wide range has yet to be determined. They are certainly more accurate than gas meters, and they are more easily comprehended.

When electricity is laid on a house it can be used for other purposes besides illumination. Mr. Sellon uses it for heating: a current of fresh warmed air passes through a coil at a temperature of about 180° Fahr. and warms water-closets and dressing-rooms. He uses it even for bed warming. I have used it for cigarette lighting, and it is frequently employed for driving sewing machines.

I am now trying charming little portable lamps, worked by secondary cells, made by

Mr. Pitkin, which enable me to visit my cellars with comfort.

TESTING.

It is most desirable that every means should be adopted in a house to test the condition of the wires and apparatus constantly. Any incipient fault in a wire would speedily develop into a serious trouble under the influence of such powerful currents as electric lighting requires. It is therefore essential to detect its existence at once. All the circuits in my house concentrate in one place on each floor, and there they are controlled by a switch. A current indicator, or galvanometer, is used, wound with a thick and a fine wire. The former indicates the number of lamps burning, and checks improper lighting; the latter detects any leakage on the wires when the lamps are removed from their holders. There is also a galvanometer in the engine-house. Secondary batteries facilitate testing. It is quite impossible for a leak to commence without its speedy detection, and if one were to appear, the particular circuit could be isolated at once by the switch.

It is often said that it is all very well for me—an expert—to rejoice over the success of electric lighting in my own house. It would be a disgrace if it were not so, but there are non-experts who have been equally successful. Mr. Walter Palmer at Reading, Sir Thomas Bazley at Fairford, Mr. Coope at Berechurch-hall, Mr. Cortauld in Essex, the Rev. Sholto Douglas in Perthshire, Mr. Tate in Streatham, and many others, have had no trouble. In fact, when the work is well done, there should be no trouble. Its working is within the reach of ordinary intelligence. As regards cost, it comes out just twice that of gas; for, though I burn no more gas than I burnt before, I have more wages to pay; there are also repairs to machinery, and the purchase of oil and waste. The lighting of my home cost me, in 1885, £60 0s. 6d.

	£	s.	d.
Gas..................	£34	9	0
Oil..................	2	5	0
Waste	0	12	0
Brushes	0	17	0
Repairs	4	9	6
Wages................	10	8	0
Lamps	7	10	0
	£60	0	6

Now, if we charge against this the value of steady light, pure air, no heat, absence of matches, candles and oil, comfort, durability of pictures decorations and books, no painters, cleanliness, cheerfulness, health, gain of time, long life, there is little doubt on which side the balance will appear.

The general distribution of electricity throughout extensive areas is a much larger question than that which I have attempted to deal with in this paper. I have endeavoured to confine myself to the past, and to the teachings of experience. The future of electric lighting in England rests very much with our Legislature, which, by the Act of 1882, has materially strengthened the monopoly of gas, by preventing the growth of a young and active competitor. There never has been one word said in favour of that Act, and it is monstrous that it should be allowed to remain on the Statutes without amendment. There seems some hope of something now being done.

APPENDIX.

TABLE I.—E.P.S. CELLS AT GOTHIC-LODGE DURING MONTH OF FEBRUARY.

Date.	E.M.F.	Ampère-hours.		Remarks.
		Put in.	Taken out.	
1	50·7	121	55	
2	51·8	64	46	
3	51·8	72	44	
4	52·8	72	38	25 cells, 15 L type.
5	51·8	81	50	
6	52·0	91	53	
7	52·2	—	41	Internal resistance 0·0015$^{\omega}$ per cell.
8	52·2	140	44	
9	52·3	—	50	
10	52·2	110	47	
11	51·8	—	50	Total put in, 1,747 ampère-hours.
12	51·8	92	30	
13	52·0	102	37	
14	52·0	—	44	Total taken out, 1,251 ampère-hours.
15	52·0	123	44	
16	52·0	—	55	
17	52·0	116	47	
18	51·8	—	40	Efficiency 72 per cent.
19	52·0	102	47	
20	52·0	61	53	Average hours of lighting—5.
21	52·0	—	42	
22	52·0	118	34	
23	52·0	—	44	
24	52·0	110	44	Average number of lamps burning—12.
25	52·0	—	45	
26	52·0	115	45	
27	52·0	57	41	
28	52·0	—	41	

TABLE II.—Charging Batteries.

Date.	Hour	E.M.F.	Current.	Hydrometer readings on cells.						Remarks.
				No. 2	No. 5	No. 14	No. 17	No. 20	No. 25	
	h. m	volts.	ampères							*March 18th.*
March 18th	8 0	57	16	1,160	1,165	1,150	1,150	1,150	1,150	Reading by meter 2,895,580
	9 0	57	18	1,160	1,165	1,150	1,150	1,150	1,150	Previous reading 2,801,650
	11 0	59	19	1,165	1,170	1,155	1,155	1,155	1,150	93,930
	12 0	60	19	1,170	1,175	1,160	1,160	1,160	1,155	
	1 0	62	19	1,175	1,180	1,165	1,165	1,165	1,165	Constant of meter, 630.
	2 0	67	19	1,175	1,180	1,170	1,170	1,165	1,165	9 ,930 ÷ 630 = 149 ampère-hours
	3 0	68	17	1,175	1,180	1,170	1,170	1,165	1,170	put into batteries.
	4 0	69	16	1,175	1,180	1,170	1.170	1,165	1,170	Average charging current = 19^a.
,, 19th	...	...	...	1,170	1,175	1,165	1,165	1,160	1 160	
,, 20th	8 0	56	16	1,165	1,170	1,155	1,155	1,155	1,150	*March 20th.* Reading by meter 2,957,760
	9 0	57	18	1 165	1,170	1,160	1,155	1,155	1,150	Previous reading 2,895,580
	10 0	59	20	1,170	1,175	1,165	1,160	1,160	1,155	62,180
	11 0	62	20	1,170	1,175	1,165	1,165	1,160	1,155	62 180 ÷ 630 = 98 ampère hours
	12 0	67	19	1,175	1 180	1 170	1,170	1,165	1,160	put in.
	1 0	69	16	1,175	1,180	1,170	1,170	1,165	1,165	Average charging current = 19·6^a
,, 21st	...	...	...	1,170	1,175	1,165	1,160	1,160	1,155	Discharge, 8·5 ampères per degree.
,, 22nd	...	...	...	1,165	1,170	1,160	1,155	1,155	1,150	

DISCUSSION.

The Chairman said he thought on a former occasion Mr. Preece had scarcely been so enthusiastic in favour of electric lighting as he had been that evening; he had given a most charming account, to some parts of which, perhaps, one or two might be inclined to take a little exception, but, on the whole, it was most encouraging and captivating. He had spoken from his own experience, and shown that electric lighting had now come within the reach of a great number of people, if not of all; and he felt convinced that the public would no longer submit patiently to the restrictions which had up to the present stood in the way of this new industry. It was this feeling which had impelled the Council of the Society to take an active part in supporting a measure which was now being introduced into the House of Lords, and which it was hoped would tend greatly to extend the facilities for introducing electric lighting into houses. The underground miner was very much troubled for want of light, and it had been lately his duty to inquire into this matter. Mr. Preece told them he had only now to take a large pocket battery into the mine, and when it was getting exhausted turn out the fluid, and fill it up again from a flask out of another pocket. In this respect he thought Mr. Preece had drawn rather a highly-coloured picture; but he would not discourage either him or the miner, in the hope that Mr. Pitkin, Mr. Blumberg, Mr. Skrivanoff, and others, would one day furnish an electric light which would do everything which was required in mining. Mr. Preece had also said some rather unkind things about horse-power and other matters, which no doubt would be commented on by some of those present.

Sir Frederick Bramwell, F.R.S., said he could not accept Mr. Preece's ideas on political economy and some other matters, quite so readily as he did his views on electric lighting. He complained that the term horse-power was unphilosophical and illogical, but he did not say why it was so; except that it was 746 times something else which was philosophical and logical. The fact was that the electricians having met in a foreign capital, and being embarrassed with grammes, centimetres, &c., would have had a unit that no one could understand, if it had not been for the practical sense of the late Sir William Siemens, who devised the name watt, and made them understand it meant $\frac{1}{746}$ of a horse-power. He could not help feeling that this was a paper for the upper classes, for gentlemen living in convenient detached houses, with gardens and gardeners, and such persons no doubt could indulge in the electric light; but he was one of the unfortunate people who had to live in London where they could, in a house in a row, and he wanted to know why he was to be debarred the use of the electric light. Except in the last paragraph, he did not think Mr. Preece had given that attention to the wants of suffering humanity generally which he should have expected from him. That last paragraph was, however, in curious contrast to some other parts of the paper. One thing which horrified Mr. Preece was monopoly. But if a man invented something which had never been known before, after years of trouble and large expenditure, why should he not be protected? The question of the Patent-laws had been discussed in that room before by eminent men fully conversant with the subject, and he would rather take their opinions when their minds were really given to the question than the *obiter dictum* of Mr. Preece on the Patent law. Mr. Preece was a Government official, and until the year 1882 the Government were not amenable to royalty, but could take any man's patented invention, and use it without payment. By the Act of 1882, however, the Government had no longer that power, and he could not help thinking that this might partly account for Mr. Preece's hostility to patent monopolies. He said he wished someone would invent a lamp which would do so and so—but why should a man invent, if he were not to get anything out of his invention? If such a lamp were brought out, and the inventor were getting something out of it, Mr. Preece would at once be down upon him, and say it was an obnoxious monopoly. He felt more interest in the last paragraph than in any other part of the paper, because it related to the restrictions on the distribution of electricity for lighting ordinary houses. Mr. Preece truly said that the monopoly of the gas companies had been increased by the restrictions on electric lighting in the Act of 1882. He did not care two straws about the monopoly of the gas companies, but it was that bugbear of monopoly which was the ground for passing the Electric Lighting Act. It was said that if it was not passed, an electric lighting monopoly would be created, and in order to prevent the capital which town councils and local boards had improperly embarked in trading enterprises being depreciated, this Act was passed which rendered competition on the part of electric lighting companies impossible. It had been in existence three years, and it was found utterly impossible to get anyone to subscribe capital to embark in an enterprise where competition with existing companies had to be met, where for years there would have been clearly no profit, and where, if there were a profit at the end of twenty-one years, the whole concern would have to be sacrificed at the value of old material, while if there were no profit, the company might keep it to themselves. People were foolish enough for almost anything, but they were not quite foolish enough for that. As had been stated by the Chairman, a Bill was being promoted, which he trusted would pass at least one House of Legislature, where they gave themselves to the study of politico-economical questions affecting the welfare of the community, and did not devote the whole of their time to mere party politics. Having regard to the nature of this Bill, its fairness, and the high character of the nobleman who had it in charge, Lord Rayleigh, one of the foremost scientific men of the day, he had little doubt that it would pass. Briefly stated, its scope was as follows. In preparing it, no favouritism towards electricity was sought; it was not the business of Government to favour any particular industry, but a young industry especially ought not to be gagged. A means had been devised by which the public were protected from monopoly on the part of gas companies, which had worked admirably, and those lines it was sought to follow. The two main features of gas legislation were the sliding scale, under which the dividend might be increased in a certain ratio to the reduction in the price of gas, while if the price went up the dividend had to be reduced; and the auction clauses, under which all new capital had to be offered to public auction, any premium obtained bearing no interest. In this way the public interest was thoroughly protected, and at the same time the companies were encouraged to lower the price as much as possible. This was the principle which was sought to be applied to the case of electric lighting, and he hoped it would pass the House of Lords. What would happen to it when it got elsewhere no one could say.

Sir Richard Webster, Q.C., M.P., said this paper was most interesting, and no doubt Mr. Preece's difficulty had been rather to know what to omit than what to include. Still there was one point on which he should like some information, and that was the cost of installation, because this was a most important consideration, both from the point of view of those who could establish private installations of their own, and also from the public point of view, where electricity was to be supplied to a large number of houses. He hoped someone would give an idea of the cost per lamp, or something of that kind, for an average house. He had had his own house lighted by electricity for nearly two years, with the most perfect success, thanks to the skill and experience of Mr. Crompton, and he rather demurred to the cost of working as given by Mr. Preece; it was well to err on the right side, but some of the items seemed to him excessive. For example, £7 10s. for lamps seemed a large sum; very possibly Mr. Preece in his good nature had been experimenting for the benefit of mankind, and had had a great many breakages, but £7 10s., at 5s. per lamp, would give 30; he had 58 lamps in his house, from 12 to 15 being used nightly, on an average, and perhaps 20 to 30 on special occasions, and he certainly had not broken six in two years. Apart from the cost of installation, he believed that when a gas-engine was used in a house where there was an intelligent man servant who could attend to it, the actual running of the electric light would not cost more than gas. He was satisfied that he did not spend more now than he used to spend on gas, oil, and candles. The most interesting portion of the paper, from the public point of view, was no doubt the question of the extension of electric lighting to those who were not able to have their own installation in the way which had been described. Sir Frederick Bramwell had intimated that the House of Commons devoted itself to nothing but party politics, but he could assure the meeting that there was a large body of the members who would be only too delighted to do what they could to promote useful legislation for the benefit of their fellow men. What they felt with regard to the Electric Lighting Act was that it had prevented the extension of this improvement amongst the classes who ought most to be considered, not in the houses of the rich, but amongst the shopkeepers and people who lived in streets, and had no facilities for engines on the premises. The great reason why there was so much hesitation among people of moderate means to adopt electric lighting was because they had already paid a considerable sum for gas pipes and fittings, which would be thrown away. Now, since the passing of the Electric Lighting Act, there had been thousands of houses built, many in squares and large clusters, to all of which electric lighting might, and to many undoubtedly would, have been applied but for the absurd restrictions which had been referred to. He did not suppose one in a hundred had even been wired for electric lighting, though it might have been done easily and cheaply, so that all in a square or gardens might have been supplied from a central station. One thing they desired to do was to cheapen the cost of installation; that the money which was now expended in gas fittings should be devoted to wires, &c., which could be done much more economically in a new house than afterwards. If £500 or £700 were spent in fitting up one house, a hundred or two more would enable two or three to be supplied from the same source. The result would be that electric lighting could be supplied from a central station at very little more than the cost of gas. In a few years it might be quite as cheap, and then the only difference would be the cost of the wires and lamps in the first instance as compared with gas fittings. If the Legislature would only see the reasonableness of this view, and prevent the electric lighting enterprise from being crushed by restrictions which had never before been imposed on any industry, and which certainly ought not to be imposed on a young industry, electric lighting would be supplied by some of the energetic persons who were connected with it at a price which would be satisfactory to the consumer, and under circumstances which would bring it within the reach of a very large number of the middle classes, and of shopkeepers, to whom, from the saving of their goods, its value would be enormous. From considerable experience he could thoroughly confirm what had been said by Sir Frederick Bramwell as to the protection of the public against gas companies by means of the sliding scale and auction clauses. He hoped the present meeting and the public generally would strengthen the hands of the Society in supporting Lord Rayleigh's Bill, and that such pressure would be brought to bear on the Government of the day as would lead to the removal of those restrictions which had hitherto stood in the way, and that then electric lighting might be brought within the reach, not of the rich only, but of those who were quite as deserving, and who had not the same facilities at their command. If that were accomplished, he was sure the trading and working classes would live to thank the Society of Arts for helping them to obtain on reasonable terms domestic electric lighting.

Mr. CROMPTON said it was very difficult to state the cost of installation, as it depended so much on varying conditions. For instance, he had to estimate for lighting such a building as Hampton Court Palace, where the wires alone would cost about £3 per light, and on other occasions for mills and factories where the same item would be as low as 4s., so that it was almost impossible to give anything like an average. One reason why the lighting was so costly at present, was that the industry was such a small one; there were not men qualified to do the work in every town, as there were gasfitters; and in the case of a house like Sir John Fowler's, in the far north, he had to send almost to the other end of England, not only for the workmen, but for those who superintended the work, so that on a job of moderate size, the expenditure for wages was very heavy. This portion of the cost would decrease in proportion as electric lighting extended, and competent men were found in every town. Those parts of the installation which were supposed to be the most expensive, such as the dynamos, and the more costly machinery, were not high now, for there had been such extensive competition that it left little room for further reduction. They hoped for much cheaper gas-engines, for their price at present was out of all proportion to that of steam-engines. In these there was no monopoly, and there was a large choice of engines fairly efficient. He could hardly agree that there were no good steam-engines suitable for private houses; there were several which could be worked by a gardener or butler just as easily as a gas-engine. He knew several which could be stoked once an hour, or three quarters of an hour, and could be kept steady, and supply power with infinitely less trouble and liability to break down than a gas-engine. Still, a gas-engine was a necessity in towns, its sole drawback being that, as had been said, it had a few tricks, but these were not such as need cause any alarm. Sir Richard Webster had been singularly fortunate in finding his own gardener able, with a few days' training, to manage his engine so as to never have a breakdown, but he must say he found gardeners were, as a rule, singularly suited for working electric lighting. They were accustomed to attend to changes of temperature in opening and shutting their glass houses; they knew that if they did not keep the temperature right they lost their plants, and did not think it any hardship to attend to the secondary batteries, and see that they were kept charged in a certain manner. He could also agree with Sir R. Webster that the cost mentioned by Mr. Preece seemed excessive; he seemed to have spent as much on gas in one year, with a 2 horse-power engine, as he

(Mr. Crompton) did in two years with a $3\frac{1}{2}$ horse-power. He had 68 lights, of which from 20 to 25 were usually in use, and his cost per annum for gas was only £15. His experience with lamps was also the same. No doubt if you made experiments you might break a great many lamps. He was supplied with enough lamps to keep his place going, even supposing they lasted the short time experimental lamps usually did; but he found that if he used the lamps originally invented by Mr. Swan, which still held a high position, a breakage of 5 per annum was the maximum. With regard to house to house lighting, which was no doubt the most important point, it was quite true that the Electric Lighting Act had had much to do with keeping back this industry. But it was only fair to say that it was only within the last six months that they had at command such appliances as would have enabled them to carry out general lighting at all. If it had not been for the excellent meter of Mr. Ferranti, there would have been no means of measuring the supply in any trustworthy manner, and any attempt to supply the light, apart from a meter, would have led to insufferable difficulties. Having tested the Ferranti meter very carefully, he had come to the conclusion that it was quite good enough for present purposes, and its perfection had removed one great stumbling block out of the path of co-operative electric lighting.

Mr. **Sellon** remarked that the interest in this subject was evidenced by the crowded state of the room. He first introduced electric lighting into his house in 1881, and should never forget the pride and happiness which he felt when the light first flashed forth, and when he showed it to his friends who had assembled on the auspicious occasion. But his pride soon had a fall, for the constant breakdowns and annoyances from the flickering and uncertainty of the light so disheartened him, that he almost wished he had never touched it. It was this sad experience which had made him turn his attention to secondary batteries, and since they had been introduced his experience had been the same as that which had already been given. He had had no difficulty, and saw no reason to regret introducing the electric light. With regard to the cost, he considered a great saving was effected. He ran about 110 lights, the average number used per night being about fifty. These were all kept going by secondary batteries, the gas engine of $3\frac{1}{2}$ horse-power being run a few hours per day. The cost per lamp per hour was $\frac{3}{4}$d., which would bear out Mr. Preece's statement of electricity being twice the cost of gas; but there were far greater considerations than the mere cost. Since 1881, he had never had to expend anything on paint. whitewashing or decoration, and this formed a substantial item on the credit side. Much scepticism had been expressed as to the life of secondary batteries, and of course there were good and bad batteries—good and bad manufacture, and good and bad treatment; but with a well made apparatus, treated with ordinary care, the difficulties disappeared. He could show batteries made four years ago which were still in perfect working order, and to the inexperienced eye they looked as good as the day they were put down; the experienced eye would perhaps detect a depreciation of about 10 per cent., but this was not much on apparatus of such a class.

Sir **David Salomons**, Bart., said he had no connection with any one engaged in electric lighting, and he spoke entirely as one of the general public. He thought Mr. Preece's estimate of cost was extremely small, because he had included nothing for depreciation; the installation would cost £600 or £700, and on that 10 per cent., or $7\frac{1}{2}$ per cent. at the least, ought to be charged. He used electricity on a large scale, employing on an average about 100 lights for 230 or 240 days in the year, and the expenditure did not exceed, with a sinking fund, £200 without interest, or £230 with it, and he considered that extremely low as compared with £60 without a sinking fund, or any other allowance. As he gathered, Mr. Preece would have the inconvenience of having to leave his bedroom after he had undressed to put out the light outside his door; he had the switch just inside the door, where it could be easily reached on entering, and of course it could be arranged to turn out the light when in bed if you pleased. He went on to describe a method by which he could detect with certainty whether any lamps were alight after a proper time, and said that, after a few discoveries of that kind had been made, he had no further trouble on that head. There was another reason why 100 or 150 volt lamps were desirable, apart from the risk of heating the lamps or destroying them. Many persons, if they had four lamps fitted up in a room, would add to or double the number, never dreaming that this added to the difficulty or danger; now, with 100 volt lamps this danger was much lessened, and besides this the lamps lasted much longer. He knew some people held a different opinion, but he had proved his view by experience. The secret was, as Mr. Preece had pointed out, that the low volt lamp got dark after a certain time, and more E.M.F. had to be used to drive the current through it, which led either to waste of energy or loss of light. The films in the 100 volt and higher lamps were thinner, and therefore there was a much less quantity of carbon deposited on the same area of glass. Such lamps would run from 800 to 1,000 hours without appreciable diminution of light.

Mr. **Preece**, in reply, said, as Sir Frederick Bramwell had left, he would not waste time in trying to convince him of the superiority of the watt to the horse-power; he would only say that instead of his knowledge of a watt being that it was $\frac{1}{746}$ of a horse-power, his knowledge of a horse-power was that it was equal to 746 watts. He did not think Sir

Frederick had quite grasped his meaning with regard to monopolies; what he objected to were grinding, grasping monopolies, such as in a few instances were a disgrace to this country. But it was quite a mistake to suppose that his ideas were in any way governed by his official position, or by the new Patent Act. He belonged to a department of the Government which always had recognised patents, and there never was an invention brought to the Post-office, patented or unpatented, by anyone, which was not well and amply rewarded. Duplex and quadruplex telegraphy, automatic apparatus, and other things had been brought to the Post-office, and nothing had ever been adopted which had not been more amply remunerated than it would have been by a private commercial company. With regard to the cost of installation, he could not say what it had cost him, but he could fit his house up again, or any house like it, for £7 10s. per lamp. A comparison had been drawn by Mr. Crompton between his cost for gas and that which he (Mr. Crompton) incurred, but when it was remembered that he had to pay 4s. 9d. per 1,000 cubic feet, which was probably nearly double that paid by Mr. Crompton, it was no wonder that his total expenditure was nearly double. It was quite true that the charge for lamps was high, for the reasons which had been suggested; he had been experimenting very freely, but since last June Mr. Upton, the manager of the Edison electric light works in New York, who came to see him, and regretted that he had not a single Edison lamp, sent him a present of 100, and out of fifty-six he had only lost three since last June. It was a very good lamp, although there was some loss of light after a time. Sir D. Salomons wanted him to allow 10 per cent. for depreciations, but he preferred following the Government system. They paid for everything out of revenue, and had no capital account on which to charge interest. Within the last two years 29,000 miles of wire and 2,000 or 3,000 new apparatus had been put up to meet the contingencies of the sixpenny telegrams, and, although this cost nearly £500,000, it was all paid out of revenue. In the same way he had fitted up his house out of revenue, the money was gone, and he should not dream of putting by 10 per cent. to bring it back again at some future time. He might say, also, that he did not find it necessary to go outside his bed-room to extinguish the light. The switches he referred to outside, were connected with what he called a "search light" placed over the door of each room, so that on going in to look for anything, he could light the room before entering. But the other lights had separate switches, and in his bed-room he had an arrangement by which he could at any moment put his hand under the pillow, and get a light immediately.

The CHAIRMAN then proposed a vote of thanks to Mr. Preece, which was carried unanimously, and the meeting adjourned.

Mr. HENRY DAVEY writes:—Mr. Preece, in speaking of the Davey motor at the Inventions Exhibition, raised as an objection the quantity of water used for condensing. It is true that it is not always convenient to provide the water necessary, but when it can be obtained from town mains, the cost does not preclude its use, and where it can be obtained without cost, as it can be in many country places, the water difficulty vanishes. I would have given some facts on this subject if there had been an opportunity. I have had the motor running for two years lighting my house. On the average, there are in use seventeen 16 candle-power lamps. The Corporation of Leeds charge £2 per annum for water, which is obtained direct from the mains. The consumption of coke is one hundred-weight per day, and the fuel is only added once in twenty-four hours. The fire burns continuously, regulated by means of an automatic damper. The only attention the motor receives is that given, one hour a day, by a labourer. I do not keep a man servant. After 5 o'clock the man goes to his home, and the motor is left to itself for the remainder of the day. At 4 o'clock the next day the man comes to fill up the boiler with coke, by that time about two-thirds empty; he wipes down the engine, oils it, and at 5 o'clock leaves. At bed time one of the household turns one tap which shuts off the motor, and another tap which stops the engine gradually, by letting in air to destroy the vacuum. So perfectly does the automatic damper keep the steam exactly at atmospheric pressure, that I am enabled to run the installation without a governor on the engine, and without a battery. The lamps are run direct from the dynamo in parallel. A week ago the governor belt of the engine broke, since then the motor has been running without a governor, and the lights have been perfectly steady. Of course I have to keep all on, but I think it is a wonderful result; in two years I have only lost one lamp. The coke costs me about £4, and the water £2 per annum. A heating coil in the house is supplied from the motor. From careful experiments I find that the consumption of steam is 30 lbs., and the consumption of water 45 gallons per independent horse-power per hour. I think such an economical result (obtained with an engine so safe that it may be placed in charge of the housemaid, and so simple that it may be started and worked by a boy or labourer) is worthy of serious attention. As to the cost of installation, I agree with Mr. Preece's figures, but I think his estimate of the cost of working very high indeed. One word as to character of fittings. I agree with Mr. Preece in what he said. One o the great charms of the electric light is that it lends itself to beautiful simplicity. My fittings cost me a few shillings. A Japanese umbrella, costing 2s. 3d., covers the "plaster vegetable" in the centre of the dining-room. From the centre, one bare lamp hangs; around it, at some distance on the umbrella, hang three other lamps, under flat glass mirrors, six inches in diameter. Another lamp on the sideboard complete the lighting of the room. The light is beautifully diffused, and there is no glare. The lamps are out of the line of sight, and are not noticed, if attention is not directed to them,—then the extreme simplicity is admired.

Miscellaneous.

COLONIAL AND INDIAN EXHIBITION.

The following notes on South Australia, Queensland, Western Australia, New Zealand, and Fiji complete the preliminary notice of Australasia:—

South Australia.

His Excellency Sir William C. F. Robinson, K.C.M.G., Governor of South Australia, is President of the Adelaide Commission, which includes amongst its members the President of the Legislative Council, the Speaker of the House of Assembly, the Attorney-General, the Minister of Education, the Presidents of the Chamber of Manufactures, the Chamber of Commerce and the Farmers' Association, and the Mayor of Adelaide. In London, Sir Arthur Blyth, K.C.M.G., Agent-General, is assisted by Sir Samuel Davenport, Assistant Executive Commissioner. Sir Samuel held an honorary position for South Australia in connection with the Exhibition of 1851, and was Special Commissioner for his colony at Philadelphia in 1876, as well as at Sydney and Melbourne.

Aboriginal and pastoral life in South Australia will be represented by a full display of wools, &c., and the timber of the colony will be prominently brought under notice. The agriculture of South Australia, its orchards, its vineyards and its olive-yards, will contribute exhibits of grains and fruits (fresh and dried)—grapes, raisins, figs, currants, almonds, oranges, lemons, apples, pears and quinces. The flora and fauna will appear in an attractive form; and the mineral wealth of the colony in copper, gold, silver, iron, bismuth, gypsum, &c., is expected to be an interesting feature in the court. The industries and manufactures will include agricultural machinery peculiar to the colony, carriages, harness, rugs, mats, brushes, hats, jewellery, woollen goods, turnery in native woods, wines, spirits, cordials, beers, jams, biscuits, olive oils, and many other articles.

Queensland.

Queensland is represented in London by the Honourable James F. Garrick, C.M.G., Agent-General, as Executive Commissioner, and by Sir James Cockle, the Honourable William Walsh and Mr. Hemmant, as Honorary Commissioners. In Brisbane, an influential Commission is presided over by the Honourable A. C. Gregory, C.M.G.

The machinery of the colony will be represented by a quartz-crushing machine, made for the Govenrment, which will be shown in action; and there will be a large and varied collection of precious stones and minerals—gathered together by Mr. A. W. Clarke, and supplemented by private exhibits—gold, argentiferous galena, copper ore, carbonates and red oxides of copper, and ingots containing lead and silver. Each gold field in the colony will be represented by a gilded block showing the total amount of quartz raised and the quantity of gold obtained; and there will also be a model of a tin mine. Like the rest of the Australian colonies, Queensland will be well represented both as regards timber and wool; and the sugar-planters are sending interesting and instructive exhibits. Mention can only be made of a few of the other industries which will contribute towards the court — furs, leathers, saddlery, meat-preserving, sugar, coffee, silk, and building stones. There will also be specimens of the work done in the Government Printing Office and Education Department. The Government botanist has sent a supply of orchids and other living plants; and a collection of fibres will be contributed by the Brisbane Museum.

Amongst the more popular exhibits will be the stuffed birds of all kinds, an alligator and a snake 25 feet long. A bush hut, a model of a completely-furnished stock-yard, and a collection of native weapons will doubtless prove of interest. A collection of pearls from the Torres Straits will be shown, and New Guinea will be represented in the court by native curiosities.

Western Australia.

A Commission of thirty-three at Perth was appointed to organise the representation of Western Australia. It contains the names of the Chief Justice, the Attorney-General, the Surveyor-General and Commissioner of Crown Lands, the Director of Public Works and Commissioner of Railways, the Mayors of Perth and Freemantle, and the Curator of the Freemantle Museum. The Executive Commissioner in London is the Hon. Malcolm Fraser, C.M.G., Colonial Secretary.

One of the prominent features of the court will be a large map of Australia, displaying the vast extent of the colony; and a popular exhibit will be a scene in the backwoods showing all kinds of timber, one of the chief products of Western Australia. There are already in the court logs of immense size—of sandal wood, and of jarrah, karri, tooart, and other examples of the Eucalyptus tribe. One short section of a jarrah trunk, which tree grows to an immense height, is over four tons in weight, and measures 4 ft. 6 in. in diameter. There are also specimens of jarrah wood which have been under water for twenty-two years, and which are still in a state of perfect preservation. A curious specimen of timber in the Court is the "raspberry-jam" tree, which gives forth an odour precisely similar to that of the preserve from which it takes its name. Western Australia will also contribute cereals, fleeces, minerals, pearls and pearl-shells, and a collection of native weapons.

NEW ZEALAND.

No list of the Commission in New Zealand has hitherto been published. In London, the interests of the colony are looked after by Sir Francis Dillon Bell, K.C.M.G., Agent-General, who is Executive Commissioner; by Dr. Julius von Haast, C.M.G., the Commissioner in charge of exhibits; and by Mr. P. L. Simmonds, the Secretary.

The two principal features of the New Zealand exhibit will be the representation of the frozen mutton industry and the fernery. The necessary freezing machinery and refrigerating chambers for the former will be placed in the Colonial Market in the South Promenade; and arrangements have been made for a constant supply of frozen New Zealand mutton, for sale in the market and for consumption in the refreshment-rooms. At the International Health Exhibition, upwards of 100,000 frozen mutton chops were sold in the refreshment-room of the School of Cookery alone; and, now that the prejudice against frozen meat in the minds of English people has been in great measure overcome, it is anticipated that a large increase in the consumption will be experienced.

For the fernery, which is being erected on the sloping bank between the New Zealand court and the south-west basin, the Government sent over a large collection of a hundred tree-ferns and four hundred other ferns, which have been housed during the winter by the Royal Horticultural Society at Chiswick. There will be, in addition, palm-trees, flax and other plants; and it is expected that the collection will be of great interest.

The following are a few of the other chief attractions which may be expected in the court. Dr. Buller will contribute upwards of 700 examples of ornithology, together with a collection of early New Zealand publications, and a miscellaneous selection of objects illustrative of the life of the Maori people—weapons, mats, carvings, and a series of life-size portraits of Maori chiefs dressed in their native costume, painted specially for him by first-rate artists. There will also be a Maori house. Mr. Reischek, the well-known naturalist, will send two fine cases of stuffed birds, one of *kiwis*, the other of *kakapos* (or large New Zealand parrot), both grouped in natural positions. The Public Works and Survey Department will be represented by a collection of the most beautiful specimens of timber obtainable, and by maps and plans. The Auckland Timber Company will show a case displaying the woods of New Zealand to the best advantage; and all the foremost cabinet makers will contribute pieces of furniture. The Mines Department have sent a complete collection of building stones, ores, and minerals generally, including specimens of the latest gold discoveries. An exhibit, showing preparations of Mahurangi lime, will attract all those who are concerned in building materials: it will display the strength of mortar made from Mount Eden scoria and lime added in proper quantities.

There will be a fine collection of topographical maps of the country, and a large number of paintings, drawings, plans and elevations of the best buildings in New Zealand, together with views of the scenery of the country; and the Government printer has sent a complete set of Government publications. A geological collection has been prepared by Dr. Hector, and the Otago Museum has been laid under contribution. Amongst other exhibits will be wool and grain, jewellery textile fabrics of native manufacture, food fishes—some stuffed and some in spirits—tobaccos, honey, bacon and other food products.

FIJI.

The Executive Commissioner in London for Fiji is the Honourable James E. Mason, M.L.C.; and Mr. Victor A. Williamson, C.M.G., Mr. A. J. Malcolm, Mr. Charles Bethell, and Mr. A. J. L. Gordon, C.M.G., are Honorary Commissioners.

A numerous General Committee at Suva is presided over by the Honourable J. B. Thurston, C.M.G., Administrator of the Government; and there are several District Committees.

At the eleventh hour space has fortunately been found for Fiji in the Australian courts—between Victoria and South Australia. One of the principal exhibits will be examples of the sugar trade.

Coffee, tobacco, arrowroot, maize, candlenuts, ropes made from cocoanut fibre, and preserved fruits will be exhibited by natives as well as by Europeans; whilst examples of tea, which is believed to be the coming industry of the islands, will be shown with reports on their quality by experts. There will also appear in the court some native curiosities—canes, cloths, fans, mats, and pottery—whilst photographs and sketches will serve to point out the magnificent scenery in which these islands abound.

Among the different kinds of timber will be the bandina or boxwood, with a view of the capital carved on it, showing its special adaptability for wood-engraving.

Correspondence.

LIGHTHOUSE ILLUMINANTS.

Some points in Mr. Price Edwards's paper require observation. I do not think that Mr. Edwards made it sufficiently plain that the lenses through which the oil light was transmitted in the experiments were 20 feet high, while the lenses for the gas light were but 16 feet high. His observation as to the respective powers of these lights is, that for revolving lights the gas had a superiority of 5 8 per cent., and for fixed lights a much greater superiority. This superiority of gas over oil would have been still more manifest had the two illuminants been tried on equal terms as to lenticular apparatus. Further, with respect to the oil light, Mr. Edwards did not mention the fact that in the case of the oil light the three lamps that were used were not burned under the same conditions as obtain in lighthouses; that is, they were not surrounded by lenticular apparatus, but had the whole air of the lantern to keep them cool. I venture to assert that it would be highly dangerous to burn them in an ordinary lighthouse apparatus, and if this be the case with three lights, how much more so with four, and if four present that difficulty, how much more is it reasonable to suppose that to burn the eight lights required for a double quadriform would be impossible. This is probably the real reason the Trinity-house would not permit my double quadriform gas light to be shown in the experiments. No oil lights could compete with it, and the electric light would be entirely beaten by it.

I observe that Mr. Edwards is quite silent as to the manner in which the electric light was manipulated, and I am not surprised at his silence, for it would not sound well in the public ear that the electric light was directed specially upon the observers, a practice perfectly inadmissible in lighthouse illumination, because the light would be invisible at all points of the horizon except that upon which it was directed. That the electric light was so manipulated is shown unmistakably in the report of the Trinity-house.

From that report, as well as from Mr. Edwards's paper, the following facts are made plain, that of the three illuminants under trial, gas, oil, and electricity, (*a*) the best form of the gas was refused admission to the trials, and the form which was admitted was shown through smaller lenses than the oil, (*b*) the oil light was not used in the same manner as if in a lighthouse, and (*c*) the electric light was improperly manipulated in the manner above described.

Mr. Edwards gives the final conclusions of the Trinity-house as follows:—"That for ordinary necessities of lighthouse illumination, mineral oil is the most suitable and economical illuminant, and that for salient headlands, important landfalls, and places where a very powerful light is required, electricity offers the greatest advantages." It is not to be wondered at that those conclusions, so little borne out, nay, so much at variance with the report itself, as well as with the evidence obtained at former trials, should be rejected by the maritime community. Take for example the case of gas. A previous investigation made at Haisho by Professor Tyndall, Dr. Valentin, and others, proved that gas was enormously greater in illuminating power than oil. Mr. Edwards acknowledges this superiority, in the case of fixed lights assigning to it 12 per cent., yet no mention whatever of gas is made in the conclusions of the Trinity-house as reported by Mr. Edwards.

Mr. Edwards's argument is that the Trinity-house was justified in rejecting the use of gas as a lighthouse illuminant, because it is more expensive than oil. Granting for a moment that such is the case, the sailor will hardly be satisfied with such a reason. He wants the best light, regardless of cost. But the fact is that the gas light, from its peculiarity of adapting its consumption to all kinds of weather, is much cheaper than oil light. For 330 nights in the year a gas burner consuming 50 feet per hour is more powerful than the ordinary oil lamp, and will show well to a horizon 30 miles distant. For the remaining 35 nights of foggy weather, which is about the annual duration of the occurrence of such weather, the gas light can be increased to eight Haisho burners of 3,000 candles each, and the extra cost for this time, though no doubt considerable, will not bring up the annual cost of the light to as great a sum as that which the inferior lights of oil will amount to. These facts will, I hope, before long be brought before the public in a manner which will ensure the fullest scrutiny, for I am sorry to be driven to the belief that the expensive and elaborate tests of the Trinity-house as to the respective powers of electricity, gas, and oil as lighthouse illuminants are absolutely valueless.

Referring to Mr. Edwards's statements as to the unlimited discretion given to Mr. Higginbotham in carrying out the gas experiments, I may refer to his letter which was published in the *Times*, in which he asserted the contrary, and pointed out the extent to which he had been fettered in his endeavours to show the best gas light; and Mr. Edwards is well aware that I have again and again called the attention of the Trinity-house to the fact that I had no control over the experiments, having been distinctly informed by the Trinity-house that I was not to interfere in any way, but to consider myself simply a contractor to carry out their bidding.

JOHN R. WIGHAM.

The name of Commander Aylesbury, the writer of the letter on "Harbours of Refuge," in the last number of the *Journal* (*ante* p. 468), was incorrectly printed *Ayleshum*.

MEETINGS OF THE SOCIETY.

ORDINARY MEETINGS.

Wednesday evenings, at Eight o'clock:—

MARCH 31.—"Methods for rendering the Blind Self-supporting." By T. R. ARMITAGE, M.D. The Right Hon. Sir HENRY SELWIN-IBBETSON, Bart., M.P., will preside.

APRIL 7.—"Preparation of Drawings for Photographic Re-production." By J. S. HODSON.

APRIL 14.—"The Treatment of Sewage." By Dr. C. MEYMOTT TIDY. Sir FREDERICK ABEL, D.C.L., C.B., F.R.S., will preside.

FOREIGN AND COLONIAL SECTION.

Tuesday evenings, at Eight o'clock :—

APRIL 13.—"The Progress of the British Possessions in the last quarter of a century." By P. L. SIMMONDS.

MAY 6.—"The Commerce and Industries of New South Wales." By EDWARD COMBES, C.M.G., President of the Board of Technical Education of New South Wales.

APPLIED CHEMISTRY AND PHYSICS SECTION.

Thursday evenings, at Eight o'clock :—

APRIL 8.—"Asbestos and its Applications." By JAMES BOYD.

INDIAN SECTION.

Friday evenings, at Eight o'clock :—

APRIL 2.—"The History of Archæology in India." By JAMES GIBBS, C.S.I., C.I.E., late Member of the Viceroy's Council. Sir GEORGE BIRDWOOD, C.S.I., Member of the Council, will preside.

MAY 7.—"Indian Manufactures from a Practical Point of View." By B. H. BADEN POWELL, C.I.E. The Right Hon. Lord HARRIS will preside.

The above dates are liable to alteration.

CANTOR LECTURES.

The Fourth Course will be on "Petroleum and its Products." By BOVERTON REDWOOD, F.C.S.

Lecture IV.—March 29.—The uses of Petroleum and its products. Illumination :—Paraffin candles, mineral oil and spirit lamps, air-gas, natural gas. Heating :—Crude Petroleum and Petroleum residuum as fuel, mineral oil stoves. Natural gas as fuel. Lubrication. Pharmaceutical.

ADDITIONAL LECTURES.

Six Elementary Lectures on "Electricity" will be delivered by Professor GEORGE FORBES, on Saturday afternoons, at Three o'clock :—

Lecture I.—April 3.—Electromotive Force and Potential.

Lecture II.—April 10.—Currents and Resistance.

Lecture III.—May 1.—Magnetism.

Lecture VI.—May 8.—Electro-magnetic Phenomena.

Lecture V.—May 15.—Induction.

Lecture VI.—May 22.—Electrical Measurement.

MEETINGS FOR THE ENSUING WEEK.

MONDAY, MARCH 29...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. (Cantor Lectures.) Mr. Boverton Redwood, "Petroleum and its Products." (Lecture IV.)

British Architects, 9, Conduit-street, W., 8 p.m.

Actuaries, The Quadrangle, King's College, W.C., 7 p.m.

Medical, 11, Chandos-street, W., 8½ p.m.

TUESDAY, MARCH 30...Royal Institution, Albemarle-street, W., 3 p.m. Prof. A. Gamgee, "New Function of Circulation." (Lecture IV.)

Civil Engineers, 25, Great George-street, S.W., 8 p.m. 1. Discussion on papers by Messrs. R. Gordon, J. R. Mosse, and G. C. Cuningham, on "The Economical Construction and Operation of Railways in newly-developed Countries, or where small returns are expected." 2. Dr. Percy F. Frankland, "Water-Purification ; its Biological and Chemical Basis."

Chemical, Burlington-house, W., 8 p.m. Anniversary Meeting.

WEDNESDAY, MARCH 31...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. Dr. T. R. Armitage, "Methods for Rendering the Blind Self-Supporting."

THURSDAY, APRIL 1...Royal, Burlington-house, W., 4½ p.m.

Antiquaries, Burlington-house, W., 8½ p.m.

Linnean, Burlington-house, W., 8 p.m. 1. Messrs. F. B. Forbes and W. B. Hemsley, "Flora of China." 2. Mr. H. N. Ridley, "African Freshwater Hydrocharideæ." 3. Mr. M. Buysman, "Vegetation of the Arctic Regions."

Chemical, Burlington-house, W., 8 p.m. 1. Prof. Ramsay and S. Young, "The Determination of Boiling Points.' "The Action of a Red Heat on Chloroform." 2. Dr. Armstrong, "The Use of the Electric Light to Influence Chemical Change." 3. Mr. S. H. Veley, "Some Compounds of Sulphur and Barium."

Society for the Encouragement of Fine Arts, 3, Conduit-street, W., 8 p.m. Mr. W. Burnham Horner, "A few Notes on the Writings of Dr. Arne, with Musical Illustrations."

Royal Institution, Albemarle-street, W., 8 p.m. Prof. Dewar, "Electro-Chemistry." (Lecture II.)

Archæological Institution, 16, New Burlington-street, W., 4 p.m.

FRIDAY, APRIL 2...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. (Indian Section.) Mr. James Gibbs, "The History of Archæology in India."

United Service Institute, Whitehall-yard, S.W., 3 p.m. Lieut. W. C. Crutchley, "The Offensive and Defensive Powers of Merchant Steamers."

Royal Institution, Albemarle-street, W., 8 p.m. Weekly Meeting 9 p.m., Mr. Howard Grubb, "Telescope Objections and Mirrors—Their Preparation and Testing."

Geologists' Association, University College, W.C., 8 p.m.

Philological, University College, W.C., 8 p.m. Dr. F. Stock, "The Heidelberg Dialect."

SATURDAY, APRIL 3...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. (Special Lecture.) Prof. George Forbes, "Electricity." (Lecture I. "Electromotive Force and Potential.")

Botanic, Inner Circle, Regent's-park, N.W., 3¾ p.m.

Royal Institution, Albemarle-street, W., 3 p.m. Mr. Howard Grubb, "The Astronomical Telescope." (Lecture II.)

CORRECTIONS.—In Professor Hartley's paper :—Page 409, col. 1, line 25, *for* elements of lines *read* elements by lines ; page 411, col. 1, last line, page 412, col. 1, line 4, *for* + *read* ±

Journal of the Society of Arts.

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FRIDAY, APRIL 2, 1886.

All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

NOTICES.

ELECTRIC LIGHTING BILL.

The following petition was presented to the House of Lords, on Thursday, 25th March, by the Duke of Abercorn, C.B., Vice-President of the Society:—

To the Right Honourable the Lords Spiritual and Temporal in Parliament Assembled.

The Humble Petition of the Society for the Encouragement of Arts, Manufactures, and Commerce, incorporated by Royal Charter,

Sheweth:—

That your Petitioners have had under consideration a Bill now before your Honourable House, intituled "An Act to Amend and Extend the Electric Lighting Act, 1882."

That your Petitioners desire respectfully to submit for the consideration of your Honourable House:—

1. That your Petitioners are satisfied it would be to the public advantage that the use of the electric light should be extended, since the light is free from any deleterious influences upon health or upon property, and is, for many purposes, and in comparison with certain illuminants, economical; while its employment would, by competition, tend to cheapen artificial lighting generally.

2. That the advantages of the light are fully appreciated is shown by the fact that notwithstanding the cost and inconvenience attaching to private installations, many large establishments have already adopted the electric light, and have found great benefit from doing so.

3. That if it is desirable to extend the use of the electric light, it is obviously necessary that it should be supplied in the same way as gas.

4. That it has been abundantly proved that there are, on the one hand, many persons willing to undertake to supply the public with the electric light, and that there exists, on the other hand, a large public demand for such light if it can be obtained.

5. That at present those willing to provide the electric light, in the same manner as gas is now provided, are hindered by the existing state of the law on the subject; and that in consequence the development of electric-lighting in this country has not been equal to its development in other countries where no such artificial hindrances exist.

6. That whereas the Electric Lighting Act, 1882, was passed under the idea that novel special provisions were necessary to protect the public against the creation of an injurious monopoly, experience has shown that in the analogous case of gas companies the public interests are sufficiently secured by the adoption of a sliding scale, under which the amount of dividend paid is regulated by the price of the commodity supplied; and by the auction clauses now introduced into gas companies' Acts, by which an efficient check is provided on the amount of capital on which a dividend can be declared.

7. That the Bill now before your Honourable House provides for the application of similar clauses to any companies which may hereafter be formed to supply the electric light to the public, and thereby secures an efficient protection against the growth of a monopoly likely to be injurious to the public interests.

8. That, having regard to the existing depression of trade, your Petitioners would strongly urge upon your Honourable House the importance of removing the obstacles to the development of a new and important industry.

Your Petitioners therefore pray that your Honourable House will take these premises into your favourable consideration, and will pass the said Bill for the amendment of the Electric Lighting Act now before your Honourable House.

And your Petitioners will ever pray, &c.

Sealed with the Seal of the Society for the Encouragement of Arts Manufactures, and Commerce, this 24th day of March, 1886, in the presence of } (L.S.)

(Signed)

F. A. Abel,
Chairman of the Council.

H. Trueman Wood,
Secretary to the Society.

CANTOR LECTURES.

The fourth and concluding lecture of the Course on "Petroleum and its Products" was delivered by Mr. BOVERTON REDWOOD, F.I.C., F.C.S., on Monday evening, March 29th. The lecturer, having referred briefly to the manufacture of paraffin candles, gave an exhaustive description of all the principal forms of mineral oil and spirit lamps and stoves used in this country, on the Continent, and in America, illustrating his remarks by referring to a very large and representative collection contributed by Sir James Douglass, Sir Frederick Abel, and all the principal manufacturers. The lecturer then described the process of wick-making, and called attention to a comprehensive series of specimens especially prepared to illustrate the various stages through which the cotton passes before it becomes a perfect wick. The principles which should govern the construction of mineral oil lamps, in order to obtain the highest illuminating power combined with safety, were then enunciated, the lecturer referring, in this connection, to the investigation in which he is at present engaged in association with Sir Frederick Abel. The relative economy of mineral oil and coal gas next received attention, the lecturer stating that, at the present respective average prices of the two illuminants, light obtained from gas was, under the ordinary conditions of domestic consumption, nearly twice as costly as light yielded by mineral oils. The manufacture and use of "air-gas," as well as of the permanent gas produced by the decomposition of mineral oils, having been described, and reference having been made to the use of natural gas for illuminating purposes, the lecturer proceeded to deal with the use of petroleum as a liquid fuel for steam-generating and metallurgical purposes, describing the various oil-burning appliances, and stating that, under ordinary circumstances, a suitable hydrocarbon fluid produced an evaporation of water per pound of fuel nearly double that obtained in the use of coal. The employment of mineral oils as lubricants, and of vaseline in pharmacy, having been disposed of, the lecturer enumerated various miscellaneous purposes for which petroleum products are used.

The collection of specimens and apparatus which has been on exhibition in the rooms of the Society of Arts will be on view till Saturday, 3rd inst.

The lectures will be published in the *Journal* during the summer recess.

Proceedings of the Society.

FOREIGN & COLONIAL SECTION.

Tuesday, March 23, 1886; Sir CHARLES TUPPER, G.C.M.G., Agent-General for the Dominion of Canada, in the chair.

The paper read was—

CANADA AND ITS NATIONAL HIGHWAY.

By ALEXANDER BEGG.

Canada is said to have been discovered by Sebastian Cabot in 1497, and in 1525 the French took possession of the country. In 1535, Jacques Cartier explored the River St. Lawrence, but it was not till 1608 that the first settlement of white men took place on the spot since known by the historic name of Quebec. In 1629, Quebec was captured by the British, and held by them till 1632, when it was retroceded to France. In 1759, it was again captured by the British forces under Wolfe, and four years later the whole of Canada became British territory by the Treaty of Paris. So that, with the exception of Quebec, Canada remained in the power of the French from the time they first took possession of the country till 1673, a period of 238 years. In 1774, a nominee council was established by Act of the British Parliament, the country in the interim having been governed by military authority. In 1791, the provinces of Upper and Lower Canada (now known as Ontario and Quebec) were created, with separate although similar forms of Government, consisting each of a Legislative Council, appointed by the Crown, and a House of Assembly, elected by the people. This plan of governing the country did not prove a success. The Houses of Assembly, especially that of Lower Canada, were in almost constant conflict with the Executive Government, until finally, in 1838, this unsatisfactory state of affairs culminated in a rebellion. On the suppression of the insurrection, the two provinces were united by Act of Parliament under one form of Government, consisting of a Legislative Council of twenty, and a House of Assembly of eighty-four members. The union thus effected did not, however, prove a harmonious one, owing to a bitter feeling of antagonism which arose between the members for Upper and Lower Canada. Matters continued in this unsatisfactory state till 1864, when a practical deadlock seemed inevitable. Then it was that the scheme for the confederation of the British North American colonies came to the fore,

In the conception, perfecting, and carrying out of this grand scheme of confederation, we find taking a prominent part such men as Sir John A. Macdonald, Sir Charles Tupper (our distinguished chairman), Sir George E. Cartier, Hon. George Brown, Sir P. Etienne Taché, Sir Alexander Galt, Sir Leonard Tilley, Sir Adams Archibald, and many other eminent colonial statesmen. These, without exception, might have been seen sinking personal and political differences, and joining hands to bring about that great scheme of union in British North America which has not only exalted Canada to the proud position she now occupies, but has also materially tended to strengthen her loyalty to the mother country. In 1867, the British North America Act was passed, and this was in truth the certificate of birth of the Dominion of Canada. At that time the confederation consisted only of the provinces of Ontario, Quebec, Nova Scotia, and New Brunswick, but in 1870 the province of Manitoba was created, and in the years 1871 and 1873 respectively, British Columbia and Prince Edward Island were incorporated in the Union. One of the first acts of the Dominion Government, under the leadership of Sir John A. Macdonald, was to send a deputation to England, in 1868, to negotiate with the Imperial authorities for the admission of Rupert's Land (now known as the North-West Territories of Canada) into confederation. Previous to that time, negotiations had been going on between the Canadian and Imperial authorities for the opening up of the North-West, and in 1865, Lord Monk forwarded copies of papers on the subject to the Right Hon. E. Cardwell, Secretary of State. Private offers from capitalists had also been made to purchase the rights of the Hudson Bay Company in the territory, so as to acquire a title to the land; but in 1866, Lord Carnarvon stepped in, and put a stop to any further negotiation of the kind. Lord Carnarvon's decision was contained in the following words:—"That no new arrangements relative to the Hudson's Bay Company are possible, pending the discussions on the proposed confederation of the British North American Provinces." The delegates sent to England in 1868 were successful, and as the result of their mission, Rupert's Land became a part of the Dominion of Canada on the 15th July, 1870. It is not necessary for the purpose of this paper to recapitulate all the particulars and incidents relating to the transfer of the North-West to the Dominion, more than to say that Canada paid to the Hudson Bay Company £300,000 sterling for the surrender of their rights, and agreed to the reservation for the benefit of the company of a twentieth part of all lands set out for settlement within fifty years after the surrender. Having thus acquired a vast territory, reaching as far west as the Rocky Mountains, the next step taken by the Government of Canada was to secure a foot-hold on the Pacific Coast, and after a series of negotiations with British Columbia, that province was incorporated in the Dominion on the 16th May, 1871.

One of the clauses contained in the agreement, under which British Columbia entered Confederation, provided for the building of the Canadian Pacific Railway within ten years. Under this arrangement the railway should have been completed in 1881, and probably would have been had the Canadian Government from the first followed out the plan it has in recent years adopted: that is, had it handed over the work to a body of energetic capitalists instead of endeavouring to carry it on as a Government undertaking. Sir John A. Macdonald, as early as 1871, foresaw this, and had almost concluded arrangements with a body of capitalists to carry on and complete the railway by 1881, when his Government was defeated in 1872. His successors strove to prosecute the work as a Government enterprise, but at the end of over six years' trial the actual completion of the road did not seem to the public of Canada to be within measurable distance.

Sir John A. Macdonald, on regaining power in 1878, endeavoured soon after to carry out his former policy, and place the construction of the national highway in the hands of energetic and competent capitalists. In spite of the most strenuous opposition, the Macdonald Government carried their point, and in 1880 Sir Charles Tupper, the then Minister of Railways and Canals, presented to the Parliament of the Dominion the text of the agreement between the Government and Mr. (now Sir) George Stephen and his colleagues for the construction of the Canadian Pacific Railway. In spite of the opposition encountered, the agreement was carried through the House, ultimately ratified by Act of Parliament, and received the Royal assent on February 16th,

1881. I can surely say, and the Dominion "Hansard" will bear me out, for it is a matter of history, that the successful carrying through of the measure relating to this important contract was due in a very large degree to the eloquence and powerful arguments of our Chairman this evening. Early in the spring of 1881 the Canadian Pacific Railway Company, under the presidency of the then Mr. George Stephen, began work, and in the autumn of 1885, that is in little over four years and a half from the date of commencement, the national highway of Canada was completed from ocean to ocean. Surely I am not wrong in saying that the successful accomplishment of this vast undertaking is one of the greatest, if not the greatest, feat of financial and engineering skill witnessed in this 19th century. Of its vast importance, from a colonial and an imperial point of view, I shall treat more in detail in the course of this paper.

It is very obvious that the most important consideration in connection with a railway is the region through which it passes, not only as to its nature and extent, but also as to its capabilities and resources. I will, therefore, briefly lay before you a few facts relative to Canada, and will then review some of the chief difficulties which were met with and overcome in the construction of the railway. With this as a basis, I will endeavour to show the importance at the present time of Canada's national highway, and the immense influence it is likely to have in the future, not only on the welfare of the Dominion, but also in assisting to maintain and render indissoluble the integrity of the British empire.

The Dominion of Canada is divided into the seven provinces already mentioned, and in addition the North-West Territories are subdivided into the following territorial districts, namely, Keewatin, Assiniboia, Saskatchewan, Alberta, and Athabasca, and these, now that settlement is progressing so rapidly, must, before long, become provinces. Canada, as a whole, contains 3,470,392 square miles, and had, according to the census of 1881, a population of 4,324,810. In 1871, the population was 3,635,024, in ten years, therefore, the increase was 689,786. Some idea may be formed of the vast extent of the Dominion by comparing it with a few of the principal European countries. Great Britain and Ireland, France, Germany, Spain, Portugal, Austria, Russia, including Finland and Poland, Italy, Turkey, and Belgium in all contain 3,471,137 square miles, with a total population of 314,544,201. Canada, therefore, with its 4½ million of people is as large as these ten European countries put together, with their population of over 300,000,000. And Canada's population continues to grow in a remarkable manner. Take for instance the population of the principal centres, namely, Montreal, Toronto, Quebec, Halifax, Hamilton, and Ottawa. These together show an increase of nearly 150,000 in the number of their citizens since 1871. The most remarkable case however is that of Winnipeg, which in 1871 did not contain over 500 inhabitants, while now it can boast of a population of between 25,000 and 30,000. The completion of the Canadian Pacific Railway and the consequent opening up of the great North-West, with its vast area of fertile land, will undoubtedly draw thousands of agriculturists from the over-crowded countries of Europe, and in this way the population of the Dominion is certain to be very materially increased within the next few years. That the North-West Territories are already filling up rapidly is evidenced on every hand. Take one instance only: the district of Assiniboia, which a year or two ago had no population to speak of, is now reputed to contain over 160,000 inhabitants. In the more eastern portions of Canada, where there is not the same room for expansion as in the North-west, We find that just half a century ago the population of Ontario was 310,000, as against 2,000,000 to-day, and Toronto, the chief city of the province, which in 1871 had 56,000 inhabitants, has now nearly 120,000.

Among the various industries of Canada, consideration is naturally first attracted to that of agriculture. There are 700,000 agriculturists in Canada, and the product of their labours totals as follows, only some of the principal products being given:—149,461,399 bushels of different kinds of grain; 103,519,641 bushels of root crops; 105,730,165 lbs. of butter and cheese; 13,377,655 bushels of apples; 3,896,508 lbs. of grapes, grown in the open air; and 5,055,810 tons of hay. The last named does not, of course, include the thousands of tons of wild hay gathered from the prairies of the North-West. Of the immense area of the Dominion there are altogether 50,000,000 of acres unoccupied, some 22,000,000 improved, and over 15,000,000 under crop, while under pasture there are over 6,000,000 acres, not, of course, including the vast prairies of the North-West, stretching, with their abundance of nutritious wild grasses, for a distance of nearly 900 miles, from the Red River to the very foot of the Rocky Mountains. The value of this natural pasturage is highly appreciated by stock raisers, and indeed, at the eastern base of the Rocky Mountains there were, in 1884, 47 ranches, ranging in extent from 1,400 to 100,000 acres each, on which cattle had been placed. Throughout the whole Dominion the live stock is estimated to number over 900,000 horses, 200,000 colts and fillies, 2,000,000 horned cattle, 1,500,000 milch cows, 1,500,000 swine, and 3,000,000 sheep, yielding over 11,500,000 pounds of wool.

The export cattle trade has grown with perhaps more rapidity than any other branch of Canadian trade with Great Britain, and, with proper care on the part of agriculturists in the selection of suitable breeds of cattle, there is every reason for the belief that the present position of Canada in this regard will be fully maintained. The number of cattle exported in 1874 from Canada to Britain was 39,623, of the value of £195,472 13s. 10d. Each year showed a gradual increase up to the year 1880, when it had reached 54,944, valued at £568,053 15s. 9d. The increase still continued, and for the season of 1885 the figures were 144,441 head, of the value of £1,557,594 12s. 1d. In horses the increase was from 5,399 in 1874, of the value of £117,238 18s. 10d., to 12,310 in 1885, of the value of £337,101 8s. 5d. In sheep the figures in 1874 were 252,081, of the value of £144,367 4s. 9d., and in 1884, 304,403, of the value of £317,395 1s. 9d.

This statement shows a wonderful increase in the cattle trade, and as the ranches of the North-West are developed, it will assuredly assume very large proportions, and is so destined to form one of the most important factors in supplying the people of Great Britain with meat. Some further idea of the rapid development of this industry in Canada may be gathered from the fact that, in Alberta alone, it is estimated, from last autumn's "round up," that there are at least 80,000 head of cattle in that district, where only a year or two ago there were comparatively few. In British Columbia, on the ranches west of the Rocky Mountains, it is computed that there are about 70,000 head of stock, and there is every likelihood that particular attention will be paid in that province to stock raising, especially as at present British Columbia expends about £200,000 annually in the importation of animals and their products. The Canadian Pacific Railway Company, fully alive to the importance of this trade, have provided stock-yards at Montreal occupying 25 acres of ground, in which there is a granary with a capacity of 400 tons of hay, grain, &c., extensive sheep and hog pens, and very capacious horse and cattle sidings. These stock-yards being close to the wharves, ocean vessels can easily load from them. The combined value of the exports of agricultural products, and animals and their produce, amounted to £7,262,695 18s. 11d. in 1884, or over one third of the whole export of the Dominion, thus clearly showing that agriculture and stock raising are the two principal industries of the Dominion.

The development of agriculture throughout the Dominion is one of the marked features of recent years, and especially is this so in the new districts of the Canadian North-West. There are now, in various North-Western districts, over one hundred flour mills, when ten years ago there were not half a dozen, the city and town mills alone having a capacity of about 3,000 barrels of flour daily. The surplus crop of wheat in Manitoba available for export in 1883-4 was 1,000,000 bushels against half that amount in 1882-3. The surplus for 1885 was over 3,000,000 bushels, though this does not include the vast wheat fields of Athabasca, Saskatchewan, and Alberta. The Canadian Pacific Railway has provided extensive accommodation for storing grain at Port Arthur on Lake Superior, and at Montreal an elevator has just been completed capable of holding 600,000 bushels, besides which there are numerous elevators erected at the various stations along the line. It is natural that the progress of agriculture in the north-west is more marked than in the older settled portions of Canada, but the progress all round is most satisfactory. In dairy farming, the Dominion has become already a formidable rival to the United States, especially in cheese exports, for up to the end of October of last year, the Canadian cargoes of cheese had exceeeded those of the port of New York by several thousand boxes, and the total export of the Dominion in this line during 1884 amounted to £1,496,599, as against £1,259,184 in 1883. In eggs, Canada exported last year no less than 11,500,000 dozen, of the total value of £500,000; and in the simple article of honey, the country raised nearly 2,000,000 lbs. last season.

Time, however, would fail me to treat further with the agricultural resources of the country, and we will, therefore, now pass on to glance at the other industries of Canada. The aggregate value of the various industries of the Dominion, according to the last census, showed a total of £33,967,416 2s. 2d. capital invested, with an output of £63,634,173 18s. 6d., and employing 287,296 hands. These figures include the minor as well as the more important industries, but in order to show the great increase in the manufacturing interests of Canada during late years, I may say that a committee was appointed in 1884 by the Canadian Government to examine into the state of certain Dominion manufactures, and the gentlemen forming that committee reported on some 725 factories throughout the different provinces. These 725 factories represented a total capital of about £10,000,000 sterling, and an output of over £15,000,000, employing nearly 60,000 hands. The works examined included a variety of manufactories, and some idea of their increase may be gathered from the fact that in the same descriptions of factories as reported on by the committee there were only 258 works in 1878, as against 725 in 1884. And as another instance of the increase in the manufacturing industries, I may mention that in cotton manufacture there were in 1874 3,514,278 lbs. of the raw material imported for manufacturing purposes, as against 19,203,569 lbs. in 1884, truly a remarkable increase. This increase in manufactures has naturally had a tendency to cheapen the price of goods, especially clothing. For instance, shirting, which cost 16½ cents. per yard in 1879, can now be bought for 11½ cents.; grey cottons are reduced from 9½ cents. to 7 cents.; woollen tweed from $1 to 75 cents. A fine knitted shirt for which a farmer paid $1 25 cents. in 1875, can now be purchased for 80 cents.; and an overcoat which cost $10 in 1875, can be obtained at present for $8, and so on, the average reduction in all kinds of clothing being from 25 to 30 per cent. Ontario is the largest manufacturing province, producing £32,446,252 3s. 2d., being over one half the total production of the Dominion. The manufactures of the Dominion are very varied, but I have neither the time nor space to enumerate them all; they include, however, cottons, woollens, machinery of all kinds, and manufactures of wood, iron, steel, brass, tobacco, sugar, and other articles.

Now, in this connection, it is most important to note that Canadian feeling is distinctly friendly to British as against foreign commerce. Statistics show unmistakeably that trade largely follows the flag. Of the total imports of Canada, in 1884, amounting to £22,229,634 17s. 1d., Great Britain furnished £8,921,805 1s. 8d., and the United States £10,375,561 9s. 2d.; but in the former case the imports consist almost entirely of manufactured articles, while in the latter they comprise chiefly raw material. Indeed, I may say that over three-fourths of the total imports of the Dominion in manufactured articles come from Great Britain, and on behalf of all the colonies I may further state that without the trade of these outlying portions of the British Empire the exports of the mother country would be reduced over one-third.[*]

The next important industry to be considered is that of the fisheries, which, in 1884, were valued at £3,645,203 12s. 1d., of which £1,765,466 15s. 1d. was exported.

In 1884, there were 1,473 vessels and 25,796 boats engaged in the different fisheries of the Dominion, with a total number of 58,822 men employed. The value of the fisheries in 1883 was £3,484,675 5s. 6d., and this, if the fisheries of Manitoba and North-West Territories were added, would show an increase of about £200,000 in favour of 1884. The salmon fisheries, especially those of British Columbia, are worthy of note, and their extent may be estimated by the fact that the total yield was valued last year at £279,105 3s. 10d. In one week alone of last season there were 12,000 cases shipped for London by the all sea route. British Columbia also excels in sturgeon, the largest captured last year weighing over 800 lbs., but they had previously been caught weighing as much as 1,400 lbs. The inland salmon fisheries of Quebec are also famous in the way of sport, and as an instance I may state that Lord Lansdowne, the Governor-General of Canada, with a small party of friends, captured last summer, during an expedition to the Cascapediac River district, no less than 400 salmon.

That Canada pays some attention to fish breeding, and, therefore, to the promotion of her fisheries, may be seen by the following list of young fish bred at the different hatcheries during 1884:—

White fish..............	30,500,000.
Pickerel................	10,000,000.
Salmon	7,390,000.
Trout	5,300,000.

Another Canadian industry deserving notice is that of lumbering, the next in importance to that of agricultural and stock raising. The total export under the head of produce of the forest was, in 1884, £5,303,873 17s., and the annual out-put in timber and logs for the same year was 111,633,862 cubic feet of different kinds of timber, 48,350,091 pine and other descriptions of logs. The forest products of Canada constitute, indeed, one of her most important sources of wealth. They find their way to all parts of the world, to the United States, the United Kingdom, and even to the Australian colonies.

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[*] The total exports of Great Britain for 1884 amounted to £295,968,000, while the imports of the colonies from the mother country, for the same time, came to £108,160,000, or nearly 10,000,000 over one-third of the total exports of the United Kingdom.

Coming now to the mineral resources of the Dominion, we find that the export of the produce of the mine in 1884 amounted to £667,232 15s. 1d. Commencing with coal, it has been ascertained that Nova Scotia possesses a coal area of nearly 700 square miles, or nearly twice the area of the Pennsylvania anthracite fields. Some of these Nova Scotian mines have a greater thickness of workable coal than probably exists anywhere in the world, and taking the province as a whole, it is estimated that there is within its boundaries three times as much coal for its area as in any other country on the face of the globe. The coal deposits in Nova Scotia commenced to be developed in 1858, and they have since grown into great importance, especially so far as the coaling of vessels is concerned; but at Sydney and Cow Bay there are mines originally opened by the French about 200 years ago, and there is one mine which has been continuously worked for no less than a century. In Nova Scotia and New Brunswick the coal area comprise about 18,000 square miles, and in the North-West Territories, between the 49th and 50th parallels of latitude, the area is, so far as known, nearly 65,000 square miles. In the Rocky Mountain range, although the areas are small as measured in miles, they contain much coal of the best quality. The immense coal fields which are known to exist in different parts of the North-West must in themselves prove to be a great boon to the settlers, and set at rest any doubts that may have existed as to the supply of fuel in that portion of the Dominion. In British Columbia, coal mining is at present next in importance to that of gold, and, in the near future, it will probably prove to be more important. The deposits are very widely spread, both on the mainland and in the islands, the coal of Nanaimo, on Vancouver Island, being so far the best that has been found on the western coast of America. All authorities agree as to the extent and value of the coal beds of British Columbia. Mr. Selwyn, the head of the Geological Survey, mentions, besides the coal beds of Queen Charlotte's Islands—some of them anthracite, and the only anthracite coal yet discovered on the Pacific coast—the Nanaimo mines, a bed in the vicinity of Barclay Sound, on the west coast of Vancouver, and beds near New Westminster, and in the neighbourhood of the Nicola Valley, on the mainland, as well as several other places.

Thirty-two different places are named by Dr. Dawson, in a report on mines published in the Report of the Geological Survey, in which coal and lignites are known to occur, and some of these are extensive districts. I should like, had time and space permitted, to have included in this paper a few of the numerous tests which have been made of Canadian coal, but may say that they have been generally of a most satisfactory character. The importance—from an Imperial point o view—of the Canadian coaling stations on the Atlantic and Pacific is fully recognised by the Imperial naval authorities. As to other minerals, gold mines are being worked in Nova Scotia, Quebec, Ontario, the North-West Territories, and British Columbia. It is now well known that certain parts of the Rocky Mountains are exceedingly rich in gold. Captain Palliser, who has recently been making investigations in the mountain districts, points out that, while before the Canadian Pacific Railway was built, such were the difficulties of transport, and of obtaining provisions and supplies, that the rich gold veins in the mountains could not be worked. Now that these obstacles are overcome, the miners are rapidly returning to the Great Bend of the Columbia River. Over 40 veins of gold-bearing quartz have already been registered, all of them situated within a radius of three miles. Along the line of the Canadian Pacific, especially on the north and north-western shores of Lake Superior, silver mining is carried on extensively. Near Port Arthur—Canada's western lake port—there are no less than six mines in operation—namely, the Huronian, Silver Mountain, Rabbit Mountain, Beaver, Silver Creek, and Turin City, while Silver Islet is declared to be the richest yet discovered on the continent. In the maritime provinces silver mining is also carried on, and in the Rocky Mountains, as well as British Columbia, rich discoveries have lately been made. Some of the Canadian iron ores are considered among the most valuable in the world, and along the shores of Lake Superior copper abounds in large quantities. Then on the line of the Canadian Pacific Railway, between Montreal and Ottawa, large deposits of phosphates are being developed. Last year alone over 25,000 tons were shipped from the district, and it is worthy of note, that in those portions of Europe where the sugar beet is extensively cultivated—that is, in France, Belgium, and Denmark—no fertiliser has been found to equal the mineral phosphate of Canada. This phosphate trade has therefore every scope for speedy and large expansion, especially as Great Britain and the United States have commenced to use the mineral extensively. The petroleum wells of Canada are famous for their wealth in oil, having in 1884 produced 15,490,622 gallons. "The Golden Butterfly," by Besant and Rice, is, indeed, no overdrawn picture of the fortunes that have been realised with oil in Canada.

The growing of fruit, as well for home consumption as for exportation, is now becoming an important industry in Canada. There are vineyards of fifty or sixty acres in extent, peach orchards of similar size; and apple orchards almost innumerable. Strawberries are raised as a field crop. Plums, pears, gooseberries, currants, and raspberries, are everywhere produced in the greatest abundance. The tomato ripens in the open air, and such is the profusion of this fruit that it is very often cheaper on the market than potatoes, selling at 2s., and some times less, per bushel. Melons ripen in the open air, as a field or market garden crop, and this delicious fruit is sold at very cheap prices in the markets. In the North-West wild fruits grow in great abundance, and include plums, grapes, strawberries, raspberries, cherries, cranberries, and other luscious berries of various kinds.

The time at my disposal prevents my giving further details regarding the resources of Canada, although it must not be supposed that I have enumerated one half the wealth of that grand Dominion of ours across the water.

The total exports of Canada in 1884 amounted to £18,782,778 1s. 7d., one half of which Great Britain received in natural products. The imports for the same period amounted to £22,229,634 17s. 1d., and of this £9,000,000 came from Great Britain in the shape of manufactured goods. Thus the exports to the United Kingdom are about evenly balanced by the imports. Canada is at the present time energetically endeavouring to extend her foreign trade relations, and negotiations, in which our worthy chairman has taken a deep and active interest, have been going on to that end with France, Spain, the West Indies, and other parts of the world. In shipbuilding, and the shipping trade, there were built in Canada during 1884, 53 steamers and 305 sailing vessels, with a tonnage of 70,287, and on the register of the Dominion there were then in all 7,254 vessels, with a nett tonnage of 1,253,747 tons. It is admitted indeed that Canada stands fifth among the maritime countries of the world. The Dominion railway system is exceeded in length by that of only five European countries, Germany, France, Great Britain, Russia, and Austria, and it is a question whether the mileage of Canada does not surpass even that of Austria. The Canadian railway system in 1884 comprised 9,949 miles of road, with 1,565 under construction (most of which have since been completed), and the capital invested amounted to £114,582,229 9s. 4d. The canal system proper of the Dominion, which is probably one of the finest in the world, comprises some 219 miles, and cost £9,605,638 5s. 9d. The trade passing through these Canadian canals reaches large dimensions. There were in all 21,722 vessels passed through the different canals in 1884, with a tonnage of 3,393,928 tons.

As to the Canadian people no better evidence exists of the prosperous condition of the working classes in a country than the state of the savings' banks, and Canada shows well in this respect, for, at the close of 1884, the sum of £2,721,778 18s. 8d. remained at the credit of depositors in the various institutions, while in 1868, the credits only amounted to £42,040 3s. 11d. So much for the wealth and resources of Canada, and to prove that her sons are able and ready to defend it should they be called upon to do so, I may mention that the enrolled active militia of the Dominion numbers 45,000 men, while the reserve is 655,000. If, however, it were necessary to defend their country against the invader, double that number would, I am sure, be forthcoming to volunteer for active service.

Of the aborigines, or, as they are sometimes called, the Red Men of Canada, there are now remaining only 131,952 throughout the whole of the Dominion, and of this number 33,959 belong to the tribes of the North-West Territories. A large proportion of the Indians in the eastern provinces are more or less civilised. Those in the North-West are so scattered, and, moreover, bound by such just and fair treaties, their part of which the Dominion Government endeavour faithfully to carry out, that any outbreak or trouble is, in my judgment, next to impossible. The attempt to incite the more important tribes to rebellion during the late rising of the half-breeds in the North-West signally failed, and no greater proof than this of their loyalty is needed. The cost to the Dominion for the maintenance and care of these Indians, and the payment of subsidies under the treaties amounted, during 1884, to £229,354 3s. 3d. These efforts by the Canadian Government to improve the condition of the Indians are not, moreover, fruitless. In 1884, on the Indian reserves, 84,586 acres were under cultivation, producing crops of corn, wheat, oats, peas, barley, rye, buckwheat, and potatoes. The fish industries of the tribes during the same period reached a value of £204,331, the fur catch £68,310, and various other industries £26,969. On the same reserves there were established, last year, 149 schools, with an attendance of 4,306 pupils, and the course of instruction included reading, spelling, writing, arithmetic, grammar, geography, history, music, singing, and drawing.

A great deal has been written about the climate of Canada. Until very recently it was looked upon as the Siberia of the British Empire. Recent investigations as to its climatic relations to European countries show that Canada has the latitudes of Italy, France, Germany, Austria, the British Islands, Russia, Sweden, and Norway; and has as many varieties of climates as have those countries. The most southern part of Canada is on the same parallel as Rome in Italy, Corsica in the Mediterranean, and the northern part of Spain —farther south than France, Lombardy, Venice, or Genoa. The northern shores of Lake Huron are in the latitude of Central France, and vast territories not yet surveyed, are favourable for all the great staples of the temperate zones. I have seen it stated in the British press that Canada, especially the North-West, experiences eight months of winter and four months of summer, while in reality the spring, summer, and autumn months are April, May, June, July, August, September, October, and part of November (frequently the greater part), and the winter months are December, January, February, and March. Fact in this case thus completely reverses fiction. The climate of the North-West is of course sometimes severe during midwinter, but as experiences of residents undoubtedly show that so dry is the atmosphere the cold is not as much felt as the readings of the thermometer would seem to threaten.

Coming now to speak briefly of the physical features and beauties of Canada. A country so vast in extent can hardly fail to present a great variety of surface, as well as every description of climate, soil, and produce. Mountain and woodland characterise to a large extent the eastern and western portions of Canada, while the central is principally level prairie. The area covered by the inland waters of the Dominion embraces 700,000 square miles, and constitutes probably the largest lake and river system in the world. Among the lakes bordering on Canada may be mentioned Ontario, Huron, Michigan, Erie, and Superior; and among those in the interior, Winnipeg, Manitoba, Great Slave, Great Bear, Athabasca, Lake of the Woods, and other minor bodies of fresh water. Among the principal rivers, the Great Saskatchewan, Mackenzie, Columbia, Fraser, and St. Lawrence, may be enumerated, and so vast are these inland waters that a vessel loading at Port Arthur, the head of Lake Superior, may pass through the various lakes, canals, and rivers to the Atlantic, a distance of about 2,384 miles, and from thence continue her voyage across the ocean.

To the tourist and sportsman Canada presents many features of interest, at which, however, I regret to say, we can only cast a passing glance. Landing at Halifax, which is an imperial station, where is kept the only garrison of British troops in Canada, a day or two can be well spent in visiting the fortifications, dockyards, and other points of interest in and around the city. The harbour of Halifax is one of the best, perhaps the very best, in the world. It is six miles long, by, on an average, a mile wide, and capable of floating alongside the wharves vessels of the largest size. There is excellent anchorage in every part of it, with room for all the navies of the world. The city and harbour of Halifax are protected by eleven different fortifications. The province of Nova Scotia, of which Halifax is the capital, is renowned for its beautiful lakes and streams, and there is excellent hunting, shooting, and fishing in almost every county. Trout abounds in nearly every stream; moose, deer, hares, and foxes, afford good sport at certain seasons, and in shooting, woodcock, snipe, plover, and duck are plentiful. The scenery in the Annapolis Valley and many other parts are we worthy of a visit. Taking the intercolonial railway, one passes from Nova Scotia through the province of New Brunswick, also famed for its fishing and for its game, of the latter the cariboo being especially plentiful. St. John, its principal city, is a great seaport, and has not inaptly been called the Liverpool of British America. Indeed the sea coast of New Brunswick is everywhere indented with commodious bays, harbours, and inlets. Its bays are well renowned for the value of their shore fisheries. Passing on we enter the province of Quebec, and soon reach the ancient city of the same name, now the present eastern terminus of the Canadian Pacific Railway. Quebec is probably the most interesting city in Canada, from a historic and scenic point of view, and well repays a visit. In the neighbourhood the Falls of Montmorenci are eight miles distant, and nine miles below the city the Chaudiere Falls. We now come to Montreal, the commercial capital of Canada, and probably the most beautiful city in the Dominion. Here is to be seen the Victoria tubular bridge, two miles in length, the work of Robert Stephenson, the great English engineer. Above are the Lachine rapids, with their wealth of wild scenery, and one of the chief attractions to excursionists visiting Montreal is to shoot these rapids in one of the river steamers, a feat which certainly possesses some considerable degree of excitement for those participating in it. Above the Lachine rapids the Canadian Pacific Railway Company are constructing a bridge to span the St. Lawrence, in order to afford the railway independent access to a seaboard connection. The bridge, which is to be of iron, substantially built on stone piers, will be 3,550 feet in length, and will cost over a million dollars. Montreal is beautifully situated on an incline, Mount Royal being in the background; and so far as its splendid wharves and piers are concerned, is in reality, as St. John hopes one day to be, the veritable Liverpool of the Dominion. It possesses many handsome public buildings, and the great Cathedral of Notre Dame is specially worthy of a visit.

We may now take the Canadian Pacific Railway to Ottawa, the seat of the federal Government in Canada, and the great timber and lumber centre of the Dominion. The Parliament buildings, consisting of three of the finest edifices on the continent of America, constitute the chief attraction of the city. The surrounding country is most picturesque, possessing many features of interest to the tourist. The water power of the Chaudiere falls at Ottawa is probably the greatest and most valuable in America. From Montreal by the Ontario and Quebec section of the Canadian Pacific Railway you reach Toronto, the chief city of Ontario. Thence a pleasant sail across the Lake Ontario brings the tourists to Niagara Falls, the splendours of which are of world-wide reputation. Toronto is built on a level plateau on the shore of Lake Ontario, and is noted for the width and beauty of its streets, and its many handsome public and private buildings. The province of Ontario, as a whole, is essentially devoted to agriculture, though, as I have already shown, its natural facilities for manufacture have been largely utilised. Yet the tourist and sportsman will find many parts worthy of front rank in his estimation, of these may be mentioned the districts of Parry Sound, Muskoka, and Nipissing, where both game and fish are plentiful.

Returning to Ottawa, we proceed by the Canadian Pacific Railway along the north of Lake Superior through a country abounding in fine scenery, and rich in minerals and timber, until we reach Winnipeg, the doorway as it were to the prairies of the North-West. The growth of Winnipeg has been, as I have already shown, wonderful, and from its position it is certainly destined to become a large and important city. The Canadian Pacific Railway runs from this point for a distance of nearly 900 miles across the great praries of the North-West to Calgary at the base of the Rocky Mountains, a great plain of fertile land destined to become, ere long, the home of thousands, aye millions, of prosperous and contented settlers. On leaving Calgary, the railway proceeds for three miles through the broad flat valley of the Bow River, and comes suddenly to the foot of a very high hill on the left, with the surging waters of the river immediately below on the right. The bridge over the Bow River consists of two spans, resting on four abutments, and measures 428 feet. Twenty miles from Calgary we pass the buildings of the extensive Cochrane Ranch, and five miles beyond we cross the Bow River for the third time by a bridge over 420 feet in length, 3,666 feet above sea level. Fifty-three miles west of Calgary, and the river is again crossed by a bridge of 470 feet, at an elevation above the sea of 4,160 feet. Farther west, the track crosses Kananaskis River, a turbulent stream tributary to the Bow River, running through a deep dark channel of slate rock, and leaping from height to height as it descends the mountain side. At Padmore, where the valley is contracted to half a mile, we make entry to the portals of the mountains. To the north the slopes are bare, to the south they are wooded. At the entry the rocks rise three to five thousand feet, showing the whole formation, and rendering the search for minerals, coal, iron, copper, and silver, comparatively easy. Four miles west of Padmore we are completely in the mountains. Every turn reveals new views of the grandest mountain scenery. Peaks tower behind and above, and now a pyramid, again a pinnacle, here an awful precipice, and there a pine-covered slope. For fifteen miles such grandeur of scenery prevails until we reach the Big Park, or Aylmer Park as some call it. Proceeding from the head of the park for eight miles, we see towering 5,800 feet above the track, Mount Cascade, named from the stream which issues from its side, and with one leap descends 2,000 feet, to the valley below, its volume becoming spray in the fall. Near Banff, seven miles westward, two sulphur springs have been discovered at a short distance from the station, on the main line. The temperature of the water in one of the springs is 73°, and in the other 200° The latter one, on the mountain side, is 200 feet above the level of the valley. It is thought that these will equal the hot springs of Arkansas.

Westward still for eight miles, and we come to Castle Mountain, named from its resemblance to Cyclopean masonry. Leaving Laggan, we pass under the shadow of the mountain, and cross wild mountain streams, and shortly stop at Stephen, named after the President of the Canadian Pacific Railway, to whom the successful prosecution of the enterprise is so largely due. This is the highest elevation on the railway, the road being 5,300 feet above the sea. Westward from Stephen the track passes several summit lakes, from one of which several streams flow on one side to the Atlantic, and on the other to the nearer waters of the Pacific. Five miles beyond is Kicking Horse Lake, whence the Kicking Horse River empties into Columbia River. The track proceeds down the Kicking Horse Valley amid scenery more magnificent even than before, to the north bank of the Beaver River, and spans the Columbia River, thence crossing the Selkirk Range by Roger's Pass, named after its discoverer, Major Rogers, an approximate distance from Stephen of 100 miles. The railway now continues for 40 miles through a valley to the second crossing of Columbia River. The line then passes through the Eagle Pass, and on through the valley of the Thompson River to Kamloops, continuing through the valley, and coasting Kamloops Lake, the track reaches Savona Ferry. Still keeping to the basin of the Thompson, and following the gorge through which the river forces its way, the railway leaves the westerly direction it has hitherto pursued, and bends down to the south. Crossing the Nicola River, we reach Lytton, near where the Thompson River enters the parent waters of the Fraser. Crossing the Fraser, the line proceeds on the western bank past Yale to Hope, where a westerly course is again resumed to Vancouver, the Pacific terminus of the Canadian Pacific Railway, completing a distance of 2,000 miles from Montreal across the Continent to the Pacific. The selection of Coal Harbour as the Pacific terminus of the railway, seems to give general satisfaction in the interests of the province and of the whole Dominion. The new port has a well-protected anchorage, while its position at a point five miles only from the mouth of the inlet is most favourable. Another important advantage over Port Moody, the terminus previously fixed upon, is that only the first narrows have to be passed, whereas, in the case of Port Moody, the second narrows, where the channel varies from 72 to 126 feet in depth, and the tide runs from three to seven knots an hour, have also to be passed.

To British Columbia time allows us to give but a passing glance. The province is undoubtedly attracting much attention at the present time in this country, now that the long looked for through railway communication over the mountain is opened up with other parts of Canada. British Columbia has not only a delightful climate, but also in many parts a rich and fertile soil. It possesses great mineral wealth and is rich in timber. The scenery on the British Columbia side of the mountains cannot be excelled, and undoubtedly it will be in the future a favourite resort for tourists and sportsmen. Its salmon fisheries, both inland and on the coast, are well known to be most valuable, and in addition trout and other kinds of fish are plentiful in the streams. Of large game there is bear, cariboo, elk, and deer, and of the smaller game wild geese, grouse, snipe, and other kinds. British Columbia is the largest, although at present the least settled, of the seven confederated provinces; now that it is linked to the rest of the Dominion, no one can say how soon it may not enter upon such a course of prosperity as to make it one of the leading provinces of Canada. There are already several indications that, as soon as the railway is open for traffic to the City of Vancouver, there will be a very considerable flow of emigration to British Columbia, so that we may expect to see within a very short time a rapid development of its numerous resources.

Having given you a very imperfect description of the resources and capabilities of the Dominion, and taken a rapid glance at the country through which passes Canada's national highway, I will now endeavour to give a short review of the difficulties encountered and overcome in the construction of the railway. During the interval between 1872 and 1878, an attempt was made to locate the line to the north of its present course. An effort was also made to utilise some of the water stretches along the route, instead of making it a continuous all-rail line across the continent. Fresh surveys were made, expensive locks were constructed, and time and money expended, only to find in the end that the part-water part-rail scheme was, for all practical purposes, a failure. I have already shown that, soon after the accession of Sir John A. Macdonald to power in 1878, a different policy was entered upon, and a contract finally effected with the gentleman now president of the road, Sir George Stephen, and his colleagues, to construct the line. The more southern route was then adopted, and work commenced in earnest, so that at the close of 1881, 165 miles were constructed westward from Winnipeg. In 1882, the company completed a further distance of 419 miles, and in December, 1883, the railway was finished to Calgary, a distance of 839 miles from Winnipeg. In the following May, 1884, it was finished to Stephen, the summit of the Rockies, being altogether a total of 961 miles, constructed in three years' time. The Government had undertaken, by the terms of their agreement with the company, to transfer, when finished, the railway already under construction and that already built, in all some 710 miles; and while the road westward from Winnipeg was being built, the line eastward to Port Arthur was completed in May, 1883, and handed over to the company to operate. The railway was therefore open from Port Arthur, on Lake Superior, to Stephen, the summit of the Rockies, in the month of May, 1884. It must not be supposed that because the work of construction was quickly done it was therefore poorly done. On the contrary, the entire line is thoroughly well built, with the very best of materials, and to show that it was well graded, I may state that the earthwork from Winnipeg to the Rockies averaged 16,300 cubic yards to the mile. The maximum gradients to the eastern base of the Rockies, with one exception, that of the crossing at the Saskatchewan River, are 40 feet to the mile, while steel rails of English and German make are used throughout the entire line. The year 1884 was principally occupied with the construction of the railway north of Lake Superior. On this section of the road, which was one of the most difficult the company had to deal with, there were from 10,000 to 12,000 men employed, and from 1,500 to 2,000 teams of horses. Twelve steamers of different sizes were employed to bring supplies to this army of labourers. The Lake Superior section was completed early in 1885, and opened for traffic in the autumn of the same year. On the 2nd of November, 1885, the first through train to the Rocky Mountains left the city of Montreal, and on the 7th of the same month, in the same year, the last spike to complete the line from the Atlantic to the Pacific was driven by the Hon. Donald A. Smith, who has been throughout one of the warmest and strongest supporters of the great enterprise. One has only to travel over the line through the Rockies to comprehend the immense physical difficulties that have been overcome in the construction of the railway. None but those who have seen them can realise their extent and immensity. More than 300 miles have been cut through solid rook; the mountains have been pierced by scores of tunnels; innumerable rivers of various sizes have been crossed, some by iron bridges over a thousand feet in length; one wooden bridge of most solid construction, 286 feet above the water, the highest in America; and no less than fourteen streams have been diverted from their natural beds by tunneling through the solid rock. The successful carrying on of this great enterprise, so far as its physical features are concerned, is quite unparalleled in railway construction. It is in magnitude and difficulty of execution one of the greatest, if not the greatest, achievement of human labour that the world has ever seen. Sir George Stephen and his colleagues, Mr. W. C. Van Horne—who was chiefly responsible for the direction, organisation, and carrying out of the work, and who promised to complete his huge task in five years, and finished it in four and a half—Sir John Macdonald, Sir Charles

Tupper, our distinguished chairman, and others who have been more or less identified with the enterprise, may justly congratulate themselves on the successful issue of their labours. The memory of the men who have thus secured for Canada what I may term the certainty of future greatness and prosperity, will never fade for generations to come. I look upon the completion of the Canadian Pacific Railway as the welding of the last link in the chain of confederation in British North America. Without that link the elements of disunion would, I fear, have developed. This is especially so far as the North-West Territories and British Columbia are concerned, for without railway connection between the eastern and western portions of the Dominion, the latter would still occupy an isolated position, such as could not last long without danger of a disruption of the union. The Canadian Pacific Railway not only strengthens confederation, but will be the means of developing in a large degree the resources of the Dominion, and with that development the railway itself must become more and more important, and can hardly fail to attain a success beyond even the expectations of its warmest friends. By its means the great prairies will be peopled, and British Columbia brought into touch with the markets of Eastern Canada, and thus the manufacturing industries of Ontario and Quebec will have room to develop and expand. Moreover, it is well known that the trade between the United States and Australasia, *viâ* California, is rapidly growing, and the class of goods supplied by our American friends to these British Colonies can be as well, if not better, supplied from Canada. Thus through the opening of the Canadian Pacific Railway a new and important outlet for Canadian goods will be secured, which must otherwise have been unattainable. The completion of the road binds together all the provinces of British North America, politically and commercially, and opens up to the surplus population of the United Kingdom the most productive wheat lands in the world. It will tend, more than any other work ever can do, to make "Greater Britain" a reality, and to consolidate in more ways than have hitherto been suspected the unity of the Empire. Viewed also merely as the opener-up of new routes, the Canadian Pacific Railway will effect for the Empire one of the most marvellous changes on record, realising to some extent the old 16th-century idea, that the shortest route to the East is by the West.

A well-known authority on International Law, writing on the complications which may arise in connection with the Suez Canal, says:—

> "England's position with regard to the Egyptian question has been greatly altered by the opening of the Canadian Pacific Railway. A free passage through the canal for our transports is by no means so essential to the defence of the Empire as it was a short time ago. We have, therefore, far greater liberty of action in dealing with the other Powers than we had before. Now that we have an alternative route to India, we may be able to purchase other advantages in the settlement of Egyptian affairs by giving our consent to an arrangement concerning the canal which prudence would formerly have compelled us to decline."

How the Canadian Pacific Railway exercises "an immediate influence upon the Eastern problem," Mr. Lawrence works out as follows:—

> "Halifax is an Imperial station, where is kept up the only garrison of British troops in the Dominion of Canada. On the receipt of a telegraphic order from the Home Government, the 2,000 or 1,500 soldiers stationed there could immediately proceed by railway across the continent. They would reach the Pacific—at the new city of Vancouver, on Burrard Inlet—in five days; and meanwhile their places at Halifax could be supplied by Canadian militia till a new garrison arrived from England. They could be conveyed from Vancouver by sea to Calcutta in 33 or 34 days, stopping on the way at Hong Kong and Singapore to pick up reinforcements from the Imperial garrisons stationed there. Thus a force of from 3,000 to 4,000 men could be thrown into India in about 38 or 39 days from the time when the order to start reached the officer in command in Halifax. Now it takes just 38 days to make the voyage from England to Calcutta, *viâ* Gibraltar and the Suez Canal. Thus we see that, as regards time, the two routes are in very much the same position; whereas the route by the Canadian railways has this great advantage—that the land portion of it passes entirely through British territory. As long as we keep command of the sea, it is perfectly safe from end to end. The canal may at any time be blocked by accident or design, but it is impossible to throw a barrier across the open ocean."

A writer of a recent article in a London paper says:—

> "The golden age of peace has not yet dawned. Hence when our Pacific squadron can with despatch and certainty draw men and supplies from Halifax or England, and when regular lines of English steamers ply between Vancouver and the East, the power and influence of Great Britain in the North Pacific will be enormously increased, whether it is to be exercised

against aggressive Russia, or to maintain her friendly ascendancy in Japan or China, or to hold her own in India.”

APPENDIX A.

TOTAL MILEAGE OF C.P.R. LINES IN 1886.

	Miles.
Main lines	3,047
Branch lines	343
Leased lines	695
	4,285

BY THE WEST TO THE EAST.—COMPARISON OF TIMES.

London to Yokohama.

P. and O. *viâ* Brindisi	43 to 46 days.
P. and O. *viâ* Gibraltar	52 to 55 ,,
C.P.R. *viâ* Vancouver	24 to 26 ,,

London to Hongkong.

P. and O. *viâ* Brindisi	34 to 37 days.
P. and O. *viâ* Gibraltar	43 to 46 ,,
C.P.R. *viâ* Vancouver	30 to 32 ,,

London to Shanghai.

P. and O. *viâ* Brindisi	39 to 42 days.
P. and O. *viâ* Gibraltar	48 to 51 ,,
C.P.R. *viâ* Vancouver	29 to 30 ,,

London to Adelaide.

P. and O. *viâ* Brindisi	38 days.
P. and O. *viâ* Gibraltar	47 ,,
Viâ New York and San Francisco	45 ,,
C.P.R. and Vancouver	35 ,,

London to Melbourne.

P. and O. *viâ* Brindisi	39 days.
P. and O. *viâ* Gibraltar	48 ,,
Viâ New York and San Francisco	44 ,,
C.P.R. and Vancouver	34 ,,

London to Sydney.

P. and O. *viâ* Brindisi	40 days.
P. and O. *viâ* Gibraltar	49 ,,
Viâ New York and San Francisco	42 ,,
C.P.R. and Vancouver	33 to 35 ,,

London to Hobart Town.

P. and O. *viâ* Brindisi	41 ,,
P. and O. *viâ* Gibraltar	50 ,,
Viâ New York and San Francisco	46 ,,
C.P.R. and Vancouver	36 ,,

London to Auckland.

P. and O. *viâ* Brindisi	45 ,,
P. and O. *viâ* Gibraltar	54 ,,
Viâ New York and San Francisco	37 ,,
C.P.R. and Vancouver	31 ,,

COMPARISON OF DISTANCES VIA NEW YORK AND SAN FRANCISCO, AND VIA CANADIAN PACIFIC ROUTES.

	Miles.
From London to Adelaide *viâ* Quebec and C.P.R.	14,444
From London to Adelaide *viâ* New York and San Francisco	14,882
From London to Melbourne *viâ* C.P.R.	13,959
From London to Melbourne *viâ* New York and San Francisco	14,397
From London to Sydney *viâ* C.P.R.	13,399
From London to Sydney *viâ* New York and San Francisco	13,837
From London to Auckland *viâ* C.P.R.	12,899
From London to Auckland *viâ* New York and San Francisco	12,687
From London to Vancouver City *viâ* Quebec and C.P.R.	6,073
From London to San Francisco *viâ* shortest connecting lines in United States	6,510
From London to Yokohama *viâ* C.P.R.	10,299
From London to Yokohama *viâ* New York and San Francisco	11,277

[The paper was illustrated by a series of lantern views thrown on the screen by means of the electric light.]

DISCUSSION.

Dr. EDMUNDS proposed a vote of thanks to Mr Begg for his interesting paper. He (Dr. Edmunds) had had the privilege of going with the British Association, two years ago, to Canada, and had seen all the places which had been represented upon the screen. Interesting as these views had been, they hardly gave a full idea of the beauty and grandeur of the places represented, those in the Rocky Mountains particularly, which surpassed anything which could be conveyed by a photograph. The interest which Englishmen had in these new colonies was very great; we were increasing at the rate of nearly 7,000 a week, and it was thought by many who were very competent to judge that England, as the workshop of the world, was meeting with very formidable rivals, and that provision for our rapidly increasing population will day by day become a more pressing question. If that were so, there could be little doubt that these new territories were most valuable possessions. He confessed that, when he travelled over those wonderful prairies and saw the farms of the prosperous settlers there, and realised that half a mile square of virgin fertile land was given to every adult emigrant who settled on those North-Western plains, he wondered how it was that our agricultural labourers could be induced to remain at their profitless toil in England, and still adhere like limpets or mussels to the rocks on which they had grown. Those who were able to bear testimony on this question ought to call the attention of our crowded population to the glorious country there was there, where everything could be had in such profusion, and where no man intending to work could fail to do well. He was so much interested by what he saw on his first visit, that last year he made a further exploration of Canada, going through some of the more northern districts. It would take twelve or eighteen months to get anything like a survey of the country, but last year he went over the Lake Winnipeg district up towards Hudson's Bay. He also travelled a second time over the great North-Western prairies, and through the Rocky Mountains, a most charming tour. As to the winter cold, Mr. Begg was quite right in his remarks; the thermometric temperature was very apt to mislead one as to the sensation of cold on the human frame. A young friend of his who had just returned from visiting the shores of Hudson's Bay, during the severest portion of last winter, told him that coming across Lake Winnipeg, they had the temperature 49° below zero, but he did not feel the cold so much as he had done in England during the last six weeks; and that when it got up to 20° below zero it seemed quite mild. It was the great dryness of the atmosphere which produced this effect. The effects of cold upon the human body was a question of the conductivity of the air, and of the rate at which the body parted with its heat. Now the extreme dryness of the air in Canada made its winter cold quite bearable. When there was a wind, a man could hardly stand it, but when there was no wind, and you were properly clothed, nothing was so exhilarating as the sleigh rides over the ice and snow which you got in Canada during certain months of the year. Mr. Begg had lived in the country more than twenty years, and had travelled all over it; he had been engaged in the fur trade, and his account could be thoroughly depended upon. He could say, from his own observation, and from what he had heard from friends, that with regard to health, and the enjoyment of life, and the success which would attend any ordinary man who went to Canada with the intention of working like a man, living frugally at first, and leading a thrifty, self-denying life, it offered a future which could not be paralleled in this country.

Mr. DAVID CHADWICK seconded the motion. He remarked on the moderate and fair manner in which Mr. Begg had treated his subject. Speaking especially of Canada's new great highway, he had been compelled naturally to omit many points of interest, but all he had said was absolutely true, and he had exaggerated nothing, but had stated the facts as briefly and fairly as possible. From his own observations on five visits to Canada, he would endeavour to say a word or two on other points which had not been referred to. On his first visit to Canada, twenty years ago, he explored the Grand Trunk Railway, which was Canada's first great highway, and, on his second visit, what was then considered to be Canada's second great highway, the Intercolonial Canadian Railway. The next time he went was for other purposes than that of railway inspection; but on his last visit he went specially to see the North-West and this Canadian Pacific Railway. It was, as Mr. Begg had described it, one of the greatest engineering works of the time; and nothing was more true than the fact that the Canadian Government (especially the present Government, which had recently at its head as Railway Minister the eminent man now in the chair) was entitled to the highest credit for carrying out this great work. Sir Charles Tupper's elaborate reports on the railways of Canada, and the mass of facts he adduced in his great speeches, demonstrated not only the practicability of the Canadian Pacific line, but that it could be made by mercantile men much better than under Government superintendence, and that it could be made to pay. No achievement could confer greater honour on Sir Charles Tupper than that which he accomplished as Railway Minister in the Government to which he was attached, and which had been so successful in every respect. When he was in Winnipeg last year, he was reminded of the fact that more than twenty years ago he had been called in as a professional accountant to report on certain matters between the old Hudson's Bay Company and the new one. Fort Garry, the site of the present city of Winnipeg, was a station of the Hudson's Bay Company. He recollected that on that occasion reports were made that in the Winnipeg valley, and the Red River settlement, fertile land could be obtained. For two or three hundred years it must have been known that the land was fertile, but it was absolutely sealed up for want of roads. But there was another railway about to be constructed which railway would open up quite a new world. The Winnipeg and Hudson's Bay was a line 600 miles long, and would give direct communication with Liverpool. It had been proved by two explorations for the Dominion Government that Hudson's Bay and Hudson's Straits were open to ordinary shipping for 4½ months in each year. This railway shortened the distance by upwards of 900 miles between Europe and the fertile plains, 200,000,000 acres in extent, of Manitoba and the North-West Territories. This new territory would afford accommodation for every human being who required a comfortable home and was willing to labour. The Hudson's Bay Railway, and the Canadian Pacific Railway would shorten the distance from Europe to British Columbia, China, and Japan, and so form a highway either for commerce, for war, or for postal communication. Mr. Hugh Sutherland, the chairman of the Winnipeg and Hudson's Bay Railway, had arrived in London that very night from Canada, but he was too much fatigued with his journey to come to the meeting. Mr. Shelford, the engineer, was present, and he would be able to substantiate his statement. The completion of this railway would be a blessing to both England and Canada.

The CHAIRMAN, in putting the motion, said he long had the pleasure of knowing Mr. Begg as one of the most indefatigable and able *employés* of the Canadian and Pacific Railway, a gentleman who, from his personal knowledge of the great Canadian North-West, with which he had long been familiar, and his thorough knowledge of every step taken by the company in the construction of this great work, would, he knew, be prepared to give a very able and interesting paper, and he could, from personal knowledge, corroborate in the fullest manner all the facts and interesting data he had given. There were none of the striking scenes which had been presented with which he was not perfectly familiar, and he only wished the audience, instead of seeing the somewhat imperfect delineations, could have seen the places themselves in their natural condition. There were one or two points, however, in the paper on which he wished to offer a slight criticism. He feared that Mr. Begg had given too much credit to himself, and to the leaders of the present Government of Canada, and had perhaps scarcely given due credit to their opponents. He said how little the Government of Mr. Mackenzie succeeded in doing, as might be gathered from the fact that at the end of over six years the actual completion of the line was about as far off as when the project was at first conceived. Now, that somewhat sweeping statement must be a little qualified in order to do justice to his political opponents. He regretted to say that they did not take the very sanguine view that he and his friends did with regard to the practicability of Canada, with a population of less than five millions, being able to undertake one of the most gigantic works of the present age, but he remembered with great gratification that when about the close of 1872 his party fell, and the opposite party succeeded to power, they declared their intention of steadily prosecuting the construction of the railway, and although no great progress was made perhaps during the five years that they were in office, it must not be forgotten that they placed under contract 228 miles of the most important and difficult section of the work, one running 112 miles east from the Red River, and another 114 running west from Port Arthur towards the Red River, the accomplishment of which greatly facilitated their efforts when they succeeded to power. During that five years also they continued vigorously to explore and survey the country, and the route by the valley of the Fraser, which was subsequently adopted, was practically located by his opponents during their term of office. Mr. Begg had stated that on their return to power, in 1878, they at once attempted to carry out the construction of the railway by a company, but that was not strictly in accordance with the fact. When they came back to power they felt that the project of constructing the railway by a company, and of obtaining capital for its construction, was in that position that it would not be wise to adopt that course immediately, and for a time they carried out the policy of their predecessors, and went on with it as a Government work. They placed under contract that very difficult portion between the two sections which their predecessors had contracted for, by which the communication would be made to Red River, and also 217 miles of the most difficult portion of the line in British Columbia, feeling assured that if the Government of Canada carried those works to a successful completion, and were then in a position to hand over to a company that completed work with a large subvention, they might induce capitalists to undertake the rest. That policy was perfectly successful, as they had heard from the author of the paper. The contract signed by him as Minister of Railways, in Batt's Hotel, Dover-street, at the close of 1880, bound Mr. Stephen and his associates to complete the road by the 1st of July, 1891, and as the lecturer had told them, that gigantic work was so far completed as to enable Mr. Donald Smith to drive the last spike last November. As Lord Lorne had said, in his interesting article in "Good Words," this was the most gigantic work of the age, and the building of it in half the time within which the contractors had bound themselves to complete it was a most wonderful achievement. He was sure the remarks of Dr. Edmunds would commend themselves to the consideration of every one present. In this over-populated country great numbers at the present time were naturally looking abroad to see if some other portion of the world did not present a better field for their industry than they could find at home, and too much importance could not be attached to the fact that, instead of their countrymen being obliged to seek under a foreign flag and in a foreign country the means of improving their position, they could, under the same flag and under British institutions, in this great Canadian North-West, find one of the most inviting fields for their industry that the world could afford. Too much importance could not be attached to the fact that this which was an unknown desert a few years ago now presented, in connection with this gigantic work, 200 million acres of the finest wheat-growing and fertile lands to be found on the face of the globe. With regard to the climate, he might give an illustration. When they talked about the thermometer going down 30° below zero one naturally felt a shudder, and asked how was it possible to survive; but there was no country in the world which would produce a larger crop of wheat than this fertile valley in the North-West of Canada, and with regard to its suitability for stock, he might mention that from his own personal knowledge of 100 horses which were turned out at the foot of the Rocky Mountains in October, worn out with their season's work, all but one were taken up in the finest condition in the spring without having had the least shelter or care of any kind, or indeed, without having been even seen by civilised eyes in the interval. That showed that, whether as regarded the production of cereals or other crops, or the effect upon animal life, there could be no finer climate, taking it all in all, than this country presented. One word upon a point touched upon by Mr. Begg, but to which too much importance could not be given, viz., the importance to this country of having an alternative route to the great East, and not being dependent on the Suez Canal or on European complications in case of war in India. The advantage of this great trans-continental Canadian Pacific Railway was not only to bring the people of this country 1,000 miles nearer to Hong Kong and Yokohama, than by the route *viâ* New York and San Francisco, but in the case of European complication, or an obstruction of the Suez Canal, England had a great highway under her own flag from end to end, by which she could send her troops; and by making a *place d'armes* at Halifax or Vancouver, she would be as near striking distance of India as by the nearest European route, which was open to obstruction. With regard to the effect of the opening of this great field for British colonisation on the Empire, and the opening up of a country which would give thoroughly happy and comfortable homes to forty millions of additional subjects; or regarded in the light of affording an alternative line to the East under the British flag, the importance of this great work could not be over-rated. Too much credit could not be given to Sir George Stephen and his associates for the vigour and courage with which they had grappled with this great work, and the service they had performed was inestimable, not only to themselves and their associates, who he believed would reap a rich reward, but for the blessings which had been conferred on their own country and the Empire at large.

Mr. H. C. BEETON, Agent-General of British Columbia, said that the Chairman, who had visited British Columbia on two occasions, knew of what importance the railway was to the Pacific province, as British Columbia had, till recently, made but slow progress. In 1849, the Hudson Bay Company undertook to colonise Vancouver, and at the end of five years the population did not exceed 450 souls. In 1858, gold was discovered, and when the rich alluvial mines of Cariboo declined, the colony experienced a severe relapse. In 1866, the island and mainland were united under the name of British Columbia. Previous to that, and dating from 1859, there were two separate Governments, one at Victoria, the other at New Westminster, with rival policies, Victoria being a free port, and New Westminster having her tariff. This year British Columbia will be within a fortnight of England, and, after long weary waiting, will be really launched on her career. Looking at her geographical position in the North Pacific, and her resources in coal, timber, minerals and fish, she seems destined to become an important manufacturing and commercial country, trading with China, Japan, and Australia. Turning to the Dominion generally and her great highway, Canada's great work in the future will be the settlement of the North-West. The emigration returns for 1885 from this country show that 70 per cent. of our people emigrate to the United States, while only 10 per cent. go to Canada. Cannot these figures be altered? Supposing an equal number went to the United States and Canada, it would have given Canada last year 70,000 instead of 20,000 emigrants. It appeared to him, in connection with the peopling of the Canadian North-West, and in colonies generally, that two important problems wait solution, one is the distribution of population, the other the distribution of food. Food was never so abundant and cheap as it is to-day. How to enable the poor to earn it is the question. Let Canada and the Mother Country co-operate in peopling the great Canadian North-West, and try to solve these two problems. By so doing, they will have conferred an everlasting blessing upon humanity.

The motion having been carried unanimously, Mr. BEGG briefly expressed his acknowledgements.

APPLIED CHEMISTRY & PHYSICS SECTION.

Thursday, March 25th, 1886; ALFRED E. FLETCHER, F.C.S., Chief Inspector under the Alkali, &c., Works Regulations Act, in the chair.

The paper read was—

ON SOME APPLIANCES FOR THE UTILISATION OF REFUSE AND DUST FUEL.

BY WALTER G. MCMILLAN, F.C.S.

Demonstrator of Metallurgy in King's College, London.

That a rigid and strict economy in material and labour is of prime importance to a commercial country is generally admitted; nevertheless, it is apt to be neglected and forgotten when the tide of prosperity is at its flood; but during the ebb, when, as at the present moment, the keen competition of British and foreign manufacturers in all the markets of the world, whether at home or abroad, combined with a high standard of wages and the universal dulness of trade, have reduced the margin of profit almost to the vanishing point, then it is that he who practises the greatest economy in his manufacturing processes, or who is able to convert the bye-products incidental to them but hitherto worthless, into a marketable article, is most likely to prove the fittest, and, therefore, to survive in the great race for public patronage. The old saying that "A penny saved is a penny gained" is thus often the key-note to success; a principle not unknown to those who have listened to many of the interesting papers read in this room. We all, I think, shall be prepared to admit that a terrible amount of waste is going on around us, a fact to which many of us may be able to testify from personal observation; but this evening, I intend to deal with this widely comprehensive subject only in so far as it concerns certain classes of refuse fuel. The vastness of our coal supply has led to carelessness as to the amount of fuel wasted, in use through imperfect appliances for its combustion, or at the mine or the works through the formation of dust. We must remember that this dust has nearly as great a heat-giving power as the fuel from which it originated (not quite as great, because it is generally mixed to a certain extent with mineral and incombustible dirt, which tends to depreciate its value proportionately), and it is of this dust that I intend to treat to-night, though I know only too well that I can render but scant justice to my subject. I propose, then, to give a brief outline sketch of the nature and production of the material, and of some of the means which have been applied to its utilisation in the past, and, finally, to give at somewhat greater length an account of one or two of the more recent inventions in this field.

PRODUCTION OF DUST FUEL.

Coal Dust.—Coal is peculiarly liable to detrition; its extreme brittleness, and low power of resistance to crushing strain, cannot but give rise to the production of much small coal and dust whenever it is handled. Whenever pyrites is present in the coal in any considerable quantity, this disintegration is largely assisted by the natural chemical process of "weathering." The first action of moist air on pyrites ($Fe\,S_2$ or bisulphide of iron) is the formation of the oxydised compound, ferrous sulphate ($Fe\,SO_4.\ 7H_2\,O$), which occupies a space nearly six-and-a-half times as great as that of the original pyrites; and thus a wedging or splitting force is brought to bear upon the surrounding coal, which becomes rapidly broken down into smaller fragments. But it is by mechanical rather than by chemical agency that coal suffers the greater deterioration. The getting of the coal in the first place, then the packing and removal in the "tubs" or trucks in which it is brought to bank, and the very process of "screening," by which the dust already present is separated from the more marketable sizes, all tend to break up the larger lumps, and thus to produce "small" at the pit itself. Then the loading of the vessels or of the railway waggons, the constant vibration and agitation of the carriages in transit, and, finally, the shooting of the coal into the store of the agent or the bunker of the consumer, give rise to a yet further supply of the inevitable dust. The proportion of dust to lump must vary with the nature of the coal; harder varieties, more capable of resisting the rough usage to which it is submitted, will yield a smaller per-centage than will the more frangible kinds; but in any case the quantity is extravagantly large. The actual waste in getting the coal depends upon its quality and upon the method of working employed, the "long wall" method yielding a smaller per-centage of dust than that known as the "pillar and stall" system.

The Table below, expanded from Smith's "Miner's Guide," published in 1836, will give some idea of the then estimated yield of three sizes of coal in various seams.

By the kindness of coal owners in a few of Midland and Northern districts of the English coal fields, I have been supplied with some statistics of the working at the present time.

Of the total coal raised (the figures given

THICKNESS OF STRATA (EXCLUDING PARTINGS) OF GETABLE COAL AND PRODUCE PER ACRE.

Coal Seam.	Thickness of seam.			Yield in Tons.			Yield per cent.		
				Coal.	Lump.	Slack.	Coal.	Lump.	Slack.
	yd.	ft.	in.						
1. Brooch coal	3	0	9	1,815	363	1,452	50	10	40
2. Flying Reed	1	1	0	3,226	645	968	66·7	13·3	20
3. Thick coal	8	2	3	10,400	1,733	3,267	67·5	11·3	21·2
4. Heathen coal	1	0	0	2,420	484	726	66·7	13·3	20
5. New Mine, top and bottom coal	4	2	6	11,695	2,339	3,508	66·7	13·3	20
6. New Mine, bottom coal	3	2	6	9,275	1,855	2,782	66·7	13·3	20
Total by Rib and Pillar System				38,831	7,419	12,703	{64·1 mean}	{12·4 mean}	{23·5 mean}
If by Long Wall system, add				10,574	2,494	3,025			
Total by Long Wall system				49,405	9,913	15,728	65·8	13·2	21

here are those representing the average work in one of the large collieries in each district). Steam coal, in the Newcastle district, gives about 30 per cent.; household coal, 35 to 45 per cent.; and gas and cooking coals, 50 to 60 per cent. of dust; in the South Durham district, about 18 per cent. is "duff;" in Derbyshire about 15 per cent. is small slack, of which 5 per cent. is left in the pit; in South Derbyshire, with an extremely soft coal, 40 per cent. is "dust," including all that will pass through a ¾-inch screen; in the Barnsley district, the hard coal gives about 5 per cent. of "smudge," the soft coal about 12 per cent.

It frequently happens that, owing to there being no demand for it in the district, or owing to the low market price, a large quantity of the small is left in the pit. Thus, in the case of the South Derbyshire soft coal above referred to, only 15 per cent. is raised, the remaining 25 per cent. being left to waste underground. All the dust that is thus allowed to remain below is, of course, absolutely lost; but unless the demand for this material increase largely, and the price to a corresponding extent, the whole quantity will not be raised, on account of the attendant expense.

The coal that is sent to bank is at some collieries in part disposed of in the condition in which it is raised, and is known as unscreened coal; but it is generally submitted to a process of screening to separate the dust or duff; frequently it is again screened to obtain intermediate sizes, these various qualities having special distinguishing names, such as round (the large coal), nuts (sometimes also treble nuts and double nuts), beans, peas, and duff. The screening process is conducted by passing the coal over parallel iron bars placed at (say) half inch distances apart, all that finds its way between these is then passed over gauze meshes, ½ inch for nuts, and ⅜ inch for peas, the finer portion thus separated being sold as duff. In the case of certain Durham collieries the proportions of the several sizes made are approximately, with present prices as loaded on wagons at pit:—

Round..	50 per cent.	@	per ton	7s. 0d. to 10s. 0d.
Nuts....	20 ,,	@	,,	4s. 6d. to 6s. 0d.
Peas....	12 ,,	@	,,	4s. 0d. to 5s. 0d.
Duff....	18 ,,	@	,,	1s. 0d. to 1s. 6d.

The price varies in different districts, ranging from zero to one-fourth or (with coking coals) one-half of the current price of best coals; thus in the Newcastle district the present price, is per ton:—

	Steam coals, f.o.b. Tyne.	House coals, f.o.b. Wear.	Coking coals. at pit.
Best	8s.	8s. 6d. to 10s. 0d.	6s. to 6s. 6d.
Small......	2s. to 2s. 6d.	3s. 0d. to 3s. 6d.	3s. to 4s. 3d.

The South Derbyshire soft coal dust, which is largely used in Jukes's furnaces, sells at 1s. 9d.; the Barnsley smudge at 1s. 6d. per ton at the present time.

Coke Dust.—As with coal itself, so with the coke produced from it in the manufacture of illuminating gas, its friable character causes it to be easily pulverised, and thus there is a large quantity of coke dust or breeze made at the numerous gas works throughout the kingdom. I am informed on, as I believe, reliable authority, that the average production of breeze at many of the metropolitan works amounts to 3·98 bushels per 10,000 cubic feet of gas, or per one ton of coal carbonised. Assuming this to be correct (and it is probably not in excess of the actual yield), and that a cubic yard weighs 947·6 lbs., equal to nearly 21 bushels, we have the following figures as the production of breeze by the metropolitan gas companies in the year 1885. The amounts of gas made, upon which the subsequent calculations are based, are taken from the annual reports of the respective companies. A bushel weighs from 42·5 to 45 lbs., according to the amount of moisture absorbed.

The price of breeze in London is about 5s. per ton delivered, or about 3s. at the gas-works; in the provinces it may frequently be had for 2s. The evaporative power of a sample containing 4·35 per cent. of ash has been determined by Mr. James Paterson of Warrington, who found it to be 11·3; that is, 1 lb. of the coke undergoing complete combustion will convert 11·3 lbs. of water at the boiling point into steam at the same temperature.

Since dust and refuse fuels are practically waste products, it is difficult to find a true estimate of the value of means proposed for their utilisation; thus, in the first place, the supply is necessarily limited, and then, with an increased demand for the material, its market price will be raised to a corresponding extent, and the consumer will derive less benefit from the use of his improved methods. This process may be very slow and gradual, but, sooner or later, if the invention have any real value, it must follow. Again, the full advantages in using the improvements can be reaped only in the immediate neighbourhood of the mines or of the works producing the

Table estimating Production of Breeze in 1885 by various Gas Companies, assuming 3·98 Bushels = 10,000 Cubic Feet of Gas.

Gas Company.	Make of gas in cubic feet.	Estimated production of breeze.		
		Bushels.	Cubic yds.	Tons.
Gas Light and Coke Company (all stations)	16,355,872,000	6,509,637	309,982	131,122
South Metropolitan Gas Company (all stations)	4,405,003,000	1,753,191	83,485	35,525
Commercial Company	1,770,000,000	704,460	33,546	14,190
Brentford and Southall Company	829,898,000	329,299	15,681	6,633
Crystal Palace District Company	596,492,000	237,403	11,305	4,782
West Ham Company	357,002,000	142,086	6,766	2,862
Tottenham and Edmonton Company	207,447,000	82,563	3,931	1,670
Wandsworth and Putney Company	205,137,000	81,644	3,888	1,644

breeze; for the expense of carriage will often exceed the prime cost of the best coal, and being the same for the lower grade fuel, the actual saving relative to the ultimate cost is much diminished.

Utilisation of the Refuse Fuels.

Coke.—If the dust result from a coal of which the powder possesses the property of binding together or caking, when heated strongly in a closed vessel, with exclusion of air, it may with advantage be used in the manufacture of coke. Previous to treating it in this way, however, it is usual to wash the dust; that is, to agitate it gently in a stream of running water; in this way, the heavier mineral impurities, with pyrites (brasses), are removed, their higher specific gravity causing them to sink to the bottom of the fluid medium, whilst the lighter combustible matter is carried forward by the stream, and deposited in suitable receptacles; thus the resulting coke has a lower percentage of ash, and, which is of yet greater consequence, contains far less sulphur than that made from unwashed coal.

The total loss in the washing, consisting of earthy and mineral matter, together with some of the coal, amounts frequently to about 15 or 20 per cent. of the original fuel. The higher price given for duff of caking coal is thus fully explained. Attempts have been made from time to time to utilise the slack of non-caking coals for producing oven-coke, by mixing it previous to carbonisation with a binding material, such as tar, or with the small of bituminous coal, but they have met with no great success.

Patent Fuel.—Another method of converting small coal into a marketable commodity is to compress it, *per se*, or in admixture with a binding substance, into the form of *briquettes*, when it has a certain sale as patent or artificial fuel; it is made chiefly for exportation, but little being used in England. This system, however, can be financially successful only so long as there is sufficient difference between the prices of dust and best coal to cover the entire cost of manufacture, with the requisite profits; and the moment this limit is reached, the manufacture of patent fuel ceases to be remunerative. The principal British seat of this industry is South Wales, though large works have been opened at Sunderland for treating Durham coal. On the Continent and in America this fuel appears to have found greater favour among engineers than it has in England, large quantities being consumed annually, especially on the railways; hence very many of the collieries in France, Belgium, and Germany, have put down plant for the manufacture of the *briquettes*, and are now treating their refuse slack with advantage.

So long ago as 1670, coke breeze appears to have been mixed with moist clay, and worked into lumps, which having been well dried, were subsequently used as a fuel. In 1799, Jean Frederick Chabannes patented a method of consolidating dust fuels, and since that time many inventors have followed in the same direction. There is necessarily a strong family likeness between the various processes, the chief points of difference being found in the nature and (especially) in the proportion of the cementing medium employed, and in the details of mechanical treatment. Although the original clay process, as we are told, is still to be found in a few obscure districts applied to the utilisation of the slack on the domestic hearth, yet, on account of the large per-centage of "ash" artifically introduced, it would not be used otherwise, where a higher class of fuel is available. In the more modern arrangements, then, the slack, in some cases washed to eliminate pyrites and heavier mineral impurities, is mixed with a liquid agglutinant, such as tar or starch mucilage, and pressed into blocks or *briquettes*, which are dried at a temperature of 150° C, and finally waterproofed, if necessary, by momentary immersion in a benzene solution of pitch; or the coal is intimately mixed in the dry condition with the necessary quantity of pitch, the mixture being then heated to the softening point of the latter, either by superheated steam or by external firing. The pasty mass may then be easily forced into the usual brick moulds by the application of powerful pressure. The use of steam is objectionable, inasmuch as the finished blocks always retain a certain amount of moisture, moreover they are said to be more liable to crack when thus prepared. One of the most recent processes is Yeadon's. The powdered coal and pitch are kept in constant motion by the revolving knives of a pug-mill, through which heated air is blown, until the mixture is sufficiently workable to allow of its being compressed into round edged *briquettes* at a pressure of two tons to the square inch. The air may, in some cases, be raised to the necessary temperature by means of the waste heat of furnace gases.

Up to this point the dust-saving plans, which I have endeavoured to sketch, have depended upon the re-integration of the matter into a solid form, of shape and size suitable to use in ordinary furnaces or grates. But of late years there have been devised a large number of schemes for utilising the dust without previous treatment, or, at least, without any attempt at agglomeration, and of these I will select a few typical instances. But in passing, I must remind you that a considerable amount of small coal is used for "mixing" in chemical operations, such as in the "black ash" process for making sodium carbonate, where it is employed to reduce to the state of sulphide the sodium sulphate formed in a previous stage, the sodium sulphide then reacting with calcium carbonate added to the charge, to form sodium carbonate and calcium sulphide. Anthracite dust, or "culm," finds an application in metallurgy, as in the smelting of tin and in the refining of copper. Brickmakers also utilise much coke breeze and coal dust. But to proceed to the consideration of

FURNACES FOR BURNING SPECIALLY PULVERISED FUEL.

In these furnaces, the arrangements for treating the dust are comparable with those generally used for gaseous, and, frequently, for liquid fuel. The coal, crushed to an uniformly small size, is injected, together with the requisite proportion of air, into the heated hearth of a reverberatory furnace, where its combustion is effected. Such is the furnace devised by Mr. T. R. Crampton.

The Crampton Furnace.—The coal is crushed in an ordinary flour-mill apparatus, or by any suitable means, until it will pass a sieve of 100 meshes to the inch; it is then, in a regular and uniform stream, discharged automatically into a current of air produced by a fan-blower, and by this it is carried forward to the injector. The injector consists of a series of bent pipes, or of an annular tube placed at the front of the furnace, through which the combustible mixture is caused to play upon the bottom or upon the sides of an initially heated combustion chamber. After thus impinging and becoming thoroughly intermixed, the heated fuel, already nearly burnt, is deflected with a slight excess of air through a narrower opening into the working-chamber of the puddling furnace or the tubes of the boiler. In a later type of revolving puddling furnace the combustion-chamber was entirely dispensed with. (See *Journal of the Society of Arts*, May 1, 1885, p. 649.) The apparatus arranged to afford a necessary control of the quantity of fuel employed, and to ensure a perfect regularity of flow, is a hopper in which the dust is constantly agitated by a pair of revolving beaters: thus it is gently forced through a lateral opening to a pair of rollers, the slow revolution of which passes a definite quantity of the dust through a shoot delivering into the air-blast. The distance between the rollers being capable of fine adjustment, the amount of dust discharged in a given time may be regulated with precision.

Whelpley and Storer's Furnace.—This furnace, which was fully described in a paper read by Lieut. C. E. Dutton before the Franklin Institute in 1871, was somewhat similar to that last described. The reduction of the fuel from the size of a coarse gravel to the fineness of flour, was effected by an arrangement of two large blowing fans, rotating rapidly on the same shaft and in the same chamber, but separated from one another by an annular diaphragm. The end of one-half of the chamber was closed tightly around the journals, this division being provided with a tangential delivery pipe; the coal was charged into the other division, and here the pulverisation was effected by the rotation of the paddles, and the mutual grinding action of the coal particles. The fine "smoke" was then drawn through the opening in the diaphragm, and discharged by the second fan directly to the furnaces.

Stephenson's Furnace.—A Cornish boiler has been arranged by Mr. G. K. Stephenson (*Engineer*, May, 1877), to burn coarsely-powdered coal by injection through a nozzle, together with the right volume of air, into a long fire-clay retort, pierced with a number of half-inch holes, and placed in the position usually occupied by the grate. To initiate the combustion, the nozzle was first heated to redness by means of an ordinary fire.

ADAPTATION OF ORDINARY BOILER FURNACES TO THE USE OF UNALTERED SMALL FUEL.

Furnaces stoked after the customary manner cannot well be fed with dust or very small fuel. The charge tends to choke the air passages, impeding, or causing great irregularity in the draught if the fire bars be placed close together; or if they be placed at the usual intervals, to pass through into the ash-pit unburnt.

Mechanical Stokers.—By regular, systematic, and even stoking, these difficulties are in part overcome. Thus a very large number of automatic feeding arrangements, known as mechanical stokers, have been brought forward at different times, but it must suffice to mention one of them which has been largely employed, and is intended to burn coal slack. In Jukes's stoker the fire bars of the usual boiler furnace are replaced by a number of short bars, linked together so as to form a series of parallel endless chains, which pass around two pulleys fixed to a movable iron frame in such wise that one pulley is in front and outside of the furnace, the other being situated beneath the bridge. The whole iron frame runs on a tramway, so that it may be rapidly removed for repairs. In order to present a level grate surface in the furnace, the chains of bars which thus run parallel with the longitudinal axis of the furnace are supported throughout their upper half (*i.e.*, the length joining the tops of the pulleys) on which the fuel rests, by a series of rollers, the lower portion (or the part passing beneath the pulleys) of course requiring no such support. In front of the furnace is the coal-hopper, provided with a sliding shutter or register, by the opening or closing of which the supply of fuel is regulated. By the revolution of the pulleys the chains of fire-bars are slowly moved, superiorly from without to within, and in the reverse direction inferiorly. It will thus be evident that a regular flow of fuel from the hopper is conveyed very slowly into the furnace by the moving bars, the rate of flow being determined by the rate of translation of the fire-bars, the amount of fuel, or thickness, depending upon the position of the register. Supposing the furnace to be already heated, gases will be evolved immediately on the entrance of the fresh fuel, and the resulting smoke mixed with sufficient air, and passing over a length of burning fuel, becomes consumed; the charge being gradually burnt as it is conveyed further into the furnace, until, finally, that portion which has reached the second pulley is completely oxidised, and nothing but ash or clinker remains, and this is removed as these links of the chain become cool whilst passing round and beneath the pullies in returning to the front of the furnace.

MARSILLY'S STEP GRATE.

M. Commines de Marsilly introduced a grate which in some of its modifications has been largely used in parts of Germany for burning gassy coal and slack in externally fired boilers. In lieu of the usual fire bars, he fixes a number of iron plates arranged so as to form a series of over-lapping steps, descending from the charging door to a short grid of five or six bars of the usual type, placed immediately in front of the bridge. The furnace is stoked by raking the fuel from each step on to that next below, and charging the fresh coal upon the top step. The air necessary to combustion enters through the vertical spaces between the plates and between the bars of the grid below.

PERRET'S PATENT BOILER FURNACE FOR DUST FUELS.

After this meagre outline sketch of past work, we must proceed to the consideration of one of the latest developments, to which I wish more particularly to call your attention this evening, viz., Perret's patent of the 30th August, 1881.

The special distinguishing features of this furnace are, a forced draught, and deep water cooled fire-bars with narrow spaces between them. These arrangements are shown in the accompanying illustrations (Figs. 1 to 4) as applied to an externally fired boiler of the elephant type, and to an internally fired single flue (Cornish) boiler. The general principles will thus be perfectly clear, and I will, therefore, quote the details of a furnace applied at the Bermondsey works of Messrs. Bryan Donkin, and Co., to a Lancashire boiler 7 feet in diameter by 22 feet in length, having two flues of 2 ft. 9 in. diameter with circulating pipes, the area of heating surface being 582 square feet. The fire bars differ widely from those commonly used; in each furnace they are arranged in two lengths, with 26 bars in each row; the bars being 2 feet long, by about three-quarters of an inch wide, by 7 inches deep at the back end, increasing to 9 inches in the front, the spaces between them being about $\frac{3}{32}$ inch, and the the total grate area in each tube 7·5 square feet. The ash-pit is closed by an air-tight door, through which is passed the pipe for delivering the blast from the blower to the fire. Within the ash-pit is a cast-iron water trough, so placed that the lowest portion of the web of every fire-bar shall be immersed in the liquid to a depth of about two inches; as the water is thus brought into close proximity to the furnace, and, moreover, becomes directly

FIG. 1.

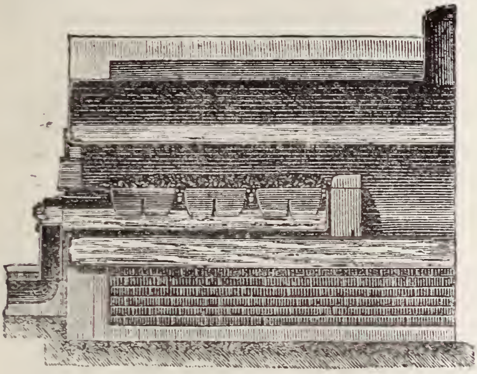


FIG. 2.

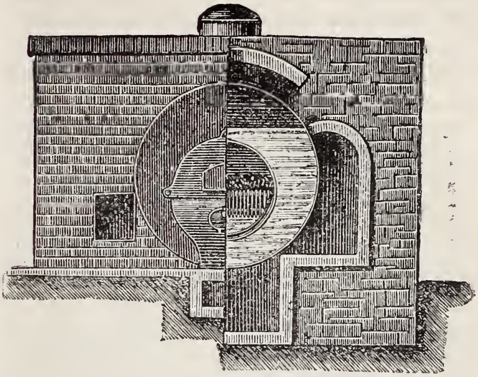


FIG. 3.

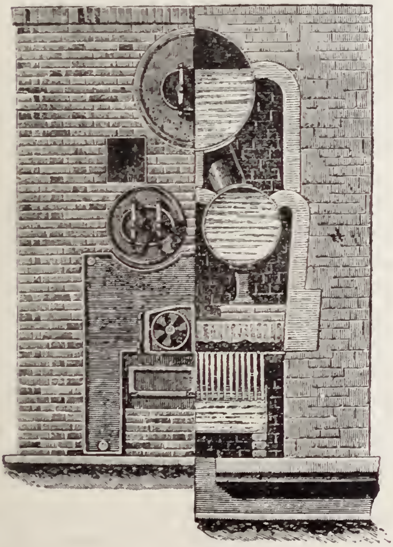
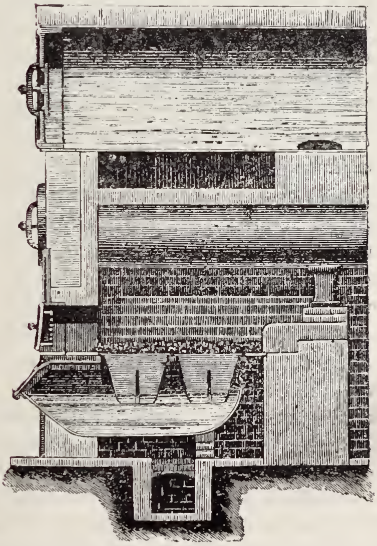


FIG. 4.



heated by conduction through the metal fire-bars, a somewhat rapid evaporation must of course take place (about 1 cubic foot per hour from each trough); and it is necessary to introduce a constant supply of fresh water sufficient to maintain the desired level in the troughs. This is accomplished by connecting them with an outside tank, whose water level is identical with that required in the troughs, and is kept constant by means of a common ball-cock, such as are fitted to house cisterns. The blast is here obtained by means of a 22-inch Lloyd's fan, running at about 1,500 to to 2,000 revolutions per minute, driven from the shafting in the shops; but there is also an alternative method of producing the required air current, in case of the failure of the fan or any similar contingency, by means of a Körting's steam injector supplied with high pressure steam direct from the boiler. The pressure of blast averages from half to one inch of water, but the lower number is preferred according to present practice. The air, then, is thus forced into a space beneath the trough, passing around the sides of which it finally finds a way vertically up between the fire-bars to the fuel above. The remaining boiler arrangements are similar to those adopted with the usual methods of firing.

The fire bars are commonly made of ϖ shape, the central slot in the web, acting as a preventive against breakage by unequal expansion at the line of water cooling. The shape may of course be varied, one of M. Perret's suggestions being, for example, a perforated plate with thin webs cast on the lower side, the webs dipping as before beneath the surface of the water; but the present arrangement is far simpler, and would, doubtless, be equally effective. By this system of water cooling, the bars are maintained at a lower temperature than is usual, they have therefore a much longer life; they preserve their shape more satisfactorily, thus maintaining constant distances between them; and moreover the clinker formed by the fusion of the coal ash does not readily adhere to them. The first indication of wear in the bars is not at the top, as is usual, but along the line where they enter the water, the joint action of air and moisture on the heated metal causing oxidation to proceed more rapidly here than at any other point.

Messrs. Donkin have now had this system in use for more than a year, and have been running it for the most part with breeze from the gas works, a fuel which ordinarily would give a great deal of trouble, but which the Perret furnace is peculiarly well adapted to burn. Screenings of bituminous or anthracitic coals might certainly be used; but in the neighbourhood of London we have no vast supply of this material, whereas the coke dust is always available. The choice of fuel depends upon the locality of the works; in coal districts the coal dust would prove more advantageous.

It may be interesting to compare the results of some of Messrs. Donkin's trials, each of eleven hours' duration, and under similar conditions, of the classes of fuel in question.

COMPARATIVE TRIALS OF COAL DUST AND BREEZE IN PERRET'S GRATE.

Class of fuel.	Fuel consumed.	Water evaporated.	Pounds of water evaporated per pound of fuel.	Cost per 1,000 gallons evaporated.	
	lbs.	lbs.		s.	d.
1. Breeze	2,800	14,300	5·1	4	4½
2. Equal weights of breeze and coal dust	3,008	17,400	5·8	5	9
3. Coal dust	2,016	15,300	7·6	5	10½
4. Welsh coal dust	2,231	15,820	7·1	6	3½

NOTE.—The evaporating power of the coal No. 4 ranges from 12 to 14 lbs. from cold feed water.

Hence, although the coal dust gives a 50 per cent. higher evaporative result than the breeze, yet, on account of the inferior cost of the latter (5s. per ton delivered at the works), it proves to be more economical in the end.

The gain by the use of the less costly fuel is still more clearly brought out by instituting a comparison between its performance in the Perret furnace, and that of lump fuel burnt in an ordinary grate applied to the same boiler. During the first three months that the new system was adopted by Messrs. Donkin, 196,458 lbs. of breeze, costing £22, was used to evaporate 929,100 lbs. of water, whilst the same boiler, under the older system, required, during a similar period in the previous year, 133,362 lbs. of lump coke, at a cost of £49, to evaporate 922,688 lbs. of water, indicating a net saving, in three months, of £27, or 55 per cent. From this amount must be deducted the trivial cost of producing the blast.

Appended is a table showing the practical result of four months of work.

RECORD OF WORK WITH PERRET'S FURNACE.

Average temperature of feed-water = 90° F.

Month in 1885	Gallons of water evaporated.	Pounds of breeze consumed.	Pounds of water evaporated per pound of fuel.	Total cost of fuel.	Cost per 1,000 gallons evaporated.
July	26,910	59,496	4·52	143s. 0d.	5s 3¾d.
August	27,050	60,246	4·49	133s. 9½d.	4s. 11¾d.
September	24,960	56,625	4·41	133s. 9d.	5s. 4½d.
November	38,670	86,366	4·47	198s. 5½d.	5s. 1½d.

The furnace burns steadily and evenly with the breeze fuel. One might reasonably expect that, on stoking a fire with a finely divided fuel, under the action of a forced draught, a large quantity of the dust would be swept forward, and deposited in the boiler flues; and to a certain extent this expectation is justified in practice. A somewhat more rapid accumulation than usual actually does occur, but it is not very great, and cleansing at two or three months' intervals is found to be amply sufficient. The sweepings may be used in the multiple stage furnace, to be described shortly. A very small amount of ash also falls between the bars, and remains in the water trough, from which it is periodically removed.

With the view of illustrating more fully the performance of the Perret boiler furnaces, I have noted the details of two experiments made by Mr. Bryan Donkin, junr., one with small coal on March 10, and the other with coke breeze on March 12 last.

Experiments with coal dust and coke breeze in Perret's boiler furnace. — The boiler is of the Lancashire type, with three Galloway tubes in each boiler tube, the smoke passing along the latter to the end, returning at the sides, meeting below and finally back underneath to the chimney. The boiler is 3 years 4 months old, and together with the flues was cleaned during the week previous to the experiment. In each trial the fire was drawn at the beginning and at the conclusion of the experiment, the grates being kept well covered, the fire doors closed as far as possible, and the damper full open.

The boiler dimensions are 21 ft. long × 7 ft. diameter, with a total heating surface of 582 sq. ft. The grates are 4 ft. long × 1 ft. 10½ in. wide = 7.5 sq. ft. in each tube or 15 sq. ft. in all.

NOTE.—In the following statement the first figures refer to the coal dust experiment, and the figures enclosed in brackets, to that with coke breeze.

Mean temperature of air inside boiler-house = 66°·4 ; [65°·5] F.

Mean temperature of air outside boiler-house = 36°·8; [34°·3] F.

Duration of trial 6 a.m. to 5 p.m. = 11 hours; [6 a.m. to 7.15 p.m. = 13¼ hours].

Average pressure of blast in inches of water = ½; [$\frac{4}{10}$].

Thickness of fuel on fire-bars = 5; [4].

Fire stoked during trial. Left-hand furnace 26 ; [50] times = 2·5 ; [3·8] per hour. Right-hand furnace 28 ; [53] times = 2·5; [4] per hour.

Temperature of smoke at exit of boiler = 376°·5 ; [399°·5] F.

(These temperature readings were taken about every 23 ; [8½] minutes).

Pressure of steam in boiler-house by Bourdon gauge, mean of 13; [17] observations = 46·2 ; [44] lbs.

Fuel.

Radford's navigation coal dust with 4·17 per cent. water at 10s. per ton.

(Gas coke breeze with 3·12 per cent. water at 5s. per ton.)

Pounds burnt during trial, not deducting water in fuel = 2,231 ; [3,360] lbs.

Pounds burnt per hour = 202·8 ; [253·6].

Pounds burnt per hour per sq. ft. of grate = 13·5 ; [16·9].

Pounds burnt per hour per sq. ft. of heating surface = 0·348 ; [0·435].

Ashes = 58 ; [68] lbs.; clinkers, 176 ; [595] lbs.; total = 234 ; [663] lbs. = 10·5 ; [19·7] per cent. of fuel.

Pounds of air (by anemometer alone) per lb. of fuel = 14·37 ; [12·1].

Feed Water (*measured by Kennedy's meter*).

Temperature of feed; mean of 17, [23] observations = 92°·9 ; [89°·3] F.

Pounds evaporated during trial = 15,820 ; [17,580].

Pounds evaporated per hour = 1,438·2 ; [1,326·7].

Pounds evaporated per hour per sq. ft. of heating surface = 2·45 ; [2·28].

Pounds evaporated per lb. of fuel consumed = 7·09 ; [5·23].

Pounds evaporated per lb. of fuel (calculating feed at 212° F.) = 8·14 ; [6·02].

Analyses of the gases showed always excess of oxygen ; no carbonic oxide was found at any time.

Evaporation from the troughs = 2·63 per cent. of that of the feed water = total of 416·06 lbs. with the small coal.

Other experiments have shown that during the night the total loss by radiation averaged 133,647 units per hour. Calculated from the above data the following balance-sheet, accounting approximately for the heat evolved during the 11 hours' trial of the small coal, may be arrived at.

The coal used has been analysed some time since and found to contain—

	Per cent.	lbs.	
Carbon ..	84·79, or	1,892	of the day's consumption of 2,231 lbs.
Hydrogen.	4·55, or	102	,, ,, ,,
Oxygen ..	2·17, or	48	,, ,, ,,
Nitrogen .	0·96, or	21	,, ,, ,,
Sulphur .	0·57, or	13	,, ,, ,,
Ash	2·79, or	62	,, ,, ,,
Water ..	4·17, or	93	,, ,, ,,
	100·00	2,231	

The evaporative power = 12·8 at 212° Fahr., found by Thompson's calorimeter. Anemometer readings of air-blast supplied, showed velocity of 2,248 feet per minute through a tube of 0·297 feet sectional area. Then taking the weight of 1 cubic foot of air at 58° Fahr. to be 0·0767 lbs., the weight of air passed during the 11 hours was (2,248 × 0·297) × 0·0767 × (60 × 11) = 33,798 lbs.

Now the carbon in the day's charge required 1,892 × $\frac{8}{3}$ = 5,045 lbs. of oxygen, to form 6,937 lbs. carbon dioxide; and the hydrogen in the day's charge required 102 × 8 = 816 lbs. of oxygen, to form 918 lbs. water; so that total oxygen required to burn coal = 5,861 lbs.; but the charge of fuel itself contained 48 lbs.; hence oxygen required from air supplied = 5,813 lbs.

But the air actually supplied contained 33,798 × $\frac{23}{100}$ = 7,773 lbs. of oxygen; deducting that absolutely required for combustion, viz.:—5,813 lbs.; the excess of oxygen supplied was 1,960 lbs.; and this is equivalent to 1,960 × $\frac{100}{23}$ = 8,522 lbs. of air; whilst the nitrogen present in the air whose oxygen was used = 5,813 × $\frac{77}{23}$ = 19,461 lbs.

BALANCE-SHEET OF HEAT UNITS (FAHRENHEIT).

	HEAT EVOLVED.		Heat units.
	2,231 lbs. of coal, evolving 12·8 × 996 heat units per lb. will give during combustion 2,241 × 12·8 × 996		28,442,573

Per cent.	HEAT ABSORBED.		Heat units.
61·5	By feed-water evaporated, 1,582 gals. at 46·2 lbs. gauge pressure:— Total heat from 32° in steam at 46 2 lbs. pressure = 1,167·5 Temperature of feed = 93°: hence {1,167 − (93° − 32)} × 15,820		17,504,830
15·3	,, Furnace gases:—		
	Excess air = 8,522 (lbs.) × 0·238 (sp. ht.) × (376·5° − 58 = 318·5)	645,993	
	Nitrogen with consumed oxygen, = 19,461 (lbs.) × 0·244 (sp. ht.) × 318·5°	1,512,392	
	Carbon dioxide formed = 6,937 (lbs.) × 0·2164 (sp. ht.) 318·5°..............................	478,122	
	Water from H in coal = 918 (lbs.) × [(212 − 58) × 1 + 966 + (376·5° − 212) × 4,805]................................	1,100,682	
	Water in coal = 93 × [(212 − 60) × 1 + 966 + (376 5 − 212) ·4805]	111,321	
	Evaporation from troughs = 416·06 × [(212 − 60) × 1 + 966 + (376·5 − 212) × ·4805]	498,031	
			4,346.541
5·2	Loss by radiation (say = night) 133,647 × 11 ...		1,470,117
18·0	Unaccounted for:—Heat in cinders,* carbon in smoke, cinders unconsumed, extra cooling, air drawn into flues between brick work and boiler, &c.		5,121.085
100			28,442 537

* There was little or no smoke.

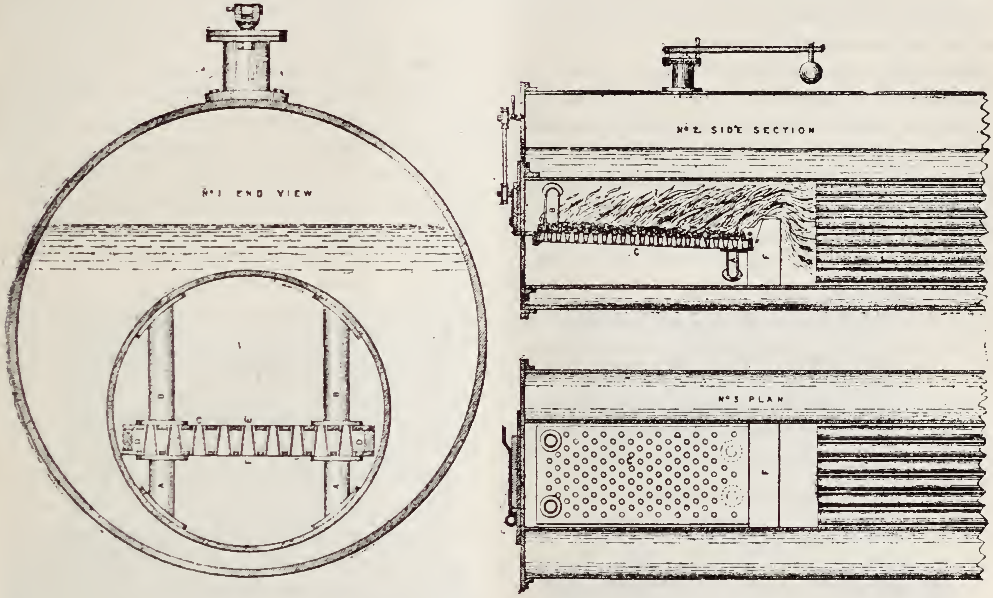
FERANDO'S PATENT MARINE BOILER FURNACE.

Signor Ferando, of Genoa, has applied forced draught to marine boilers, and he, like Perret, uses closed ash pits, communicating with a reservoir continuously charged with air from a fan blower. The fan is driven by a small engine, deriving its motive power from the main boiler when at sea, or from the donkey boiler when in harbour, the pressure employed being equal generally to about one inch of water. Finding that, with ordinary longitudinal fire-bars, the draught did not pass evenly through the narrow apertures, he arranges his bars transversely. They are 17 inches long, by $\frac{7}{16}$ inch in width at the top, tapering to $\frac{3}{16}$ inch at the bottom, by 4 inches in maximum depth, and are placed with $\frac{1}{16}$ inch distances between them at the top, this space increasing to $\frac{5}{16}$ inch at the lowest point. Instead of dipping the bars into a water trough, as in the furnace last described, Ferando injects a water spray on to the floor of the ash pit, and depends upon the cooling action of the resulting aqueous vapour to prevent overheating. If, in spite of this, and before a protective covering of clinker is formed, the bars should tend to overheat, a small quantity of steam from the boiler is turned into the ash-pit for a short time. This system has been applied to several Italian ships within the last year, and Messrs. Scott Brothers, of Newcastle, have recently adapted it to the boilers of their s.s. *Odiel*, and, I believe, are now fitting other vessels on the same principle. They are burning Ryhope duff, containing 7 per cent. of ash, and costing

2s. 9d. per ton, free on board (against 7s. 6d. per ton = price of the old fuel); and they inform me that, in the last voyage made by the *Odiel*, the small gave steaming results equal to the large coal, 11½ tons only being used instead of 12 tons of bunker coal formerly employed, the actual consumption of duff being 1·84 lbs. per indicated horse-power. A trial trip of the *Odiel* over the measured mile, on the 20th ult., is reported in the daily Press as having shown a speed of 9·408 miles in a rough sea, the engines giving from 67 to 68 revolutions with a pressure of over 70 lbs. Combustion is practically complete, about $\frac{3}{8}$ inch of a hard bare clinker forming on the bars, the amount passing through into the ash-pit in the course of an eleven days' voyage being very trifling.

GREEN'S PATENT WATER-HEARTH FOR BOILERS.

Fig. 5



From the construction of this furnace, which at present is used for ordinary lump coal in internally fired boilers, and is especially suited to the combustion of anthracite and highly carbonaceous fuels, I should imagine that it might be readily adapted to the utilisation of slack. From the accompanying sketch* (Fig. 5) it will be seen that in the position generally occupied by the fire-bars (which in this furnace are entirely dispensed with), is a shallow cistern or water box constructed of boiler plate; the top plate is perforated with a sufficient quantity of small holes; and in corresponding positions in the lower plate are a like number of apertures of somewhat greater diameter. Each pair of holes is fitted with a conical tube, firmly screwed into the plates, which are thus securely riveted together, and at the same time pierced with passages forming air communications between the furnace and the ash-pit. A constant flow of water is maintained through the water box, and thus around the conical tubes, by two pipes passing from the front end of the box downwards through the ash-pit, and so making connection with the lower part of the boiler; and by two leading upwards, in the direct path of the flame and heated gases, at the bridge where it joins the upper portion of the boiler. In this manner the circulation of water in the boiler is promoted, and the grate is not heated to a temperature at which the iron would be damaged, but, on the contrary, its heat is communicated at once to the water in the box, which thus actually becomes a part of the boiler itself. The air supply passes through these tubes, which, however, permit ashes to fall into the ash-pit beneath, and would thus be a source of inconvenience if small fuel were used; but by subdividing or obstructing the apertures, one would predict that either with or without forced draught a more pulverulent fuel might well be burnt.

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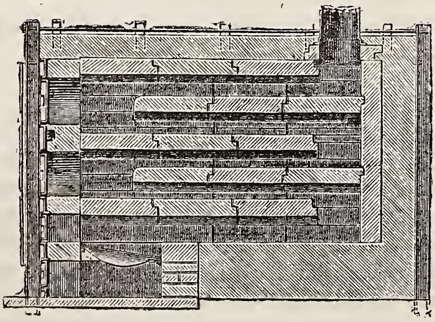
* This, the original type of furnace, has lately been improved as explained in the text—the tubes joining the water-box with the upper half of the boiler being now placed at the bridge end, the downward tubes at the door end of the grate.

PERRET'S PATENT MULTIPLE STAGE FURNACE.

Leaving now the application of dust fuels to boiler heating, let us turn our attention for a few minutes to two other furnaces, devised by M. Perret, specially to burn fuels far inferior even to those of which we have been treating hitherto—for instance, such highly unpromising material as the sweepings of boiler flues, and the like.

You may remember that M. Perret has given us a pyrites burner for use in the manufacture of vitriol, where the roasting mineral is spread out on a series of large superposed trays, over which the air alternately passes until the free oxygen is entirely replaced by sulphur dioxide; the calcination (when once initiated) being effected by the heat of combustion of the oxidising pyrites. Finding this to be successful, he has since applied the same principle to the utilisation of the lowest grade fuels, when high temperatures are not required, as *e.g.*, in the heating of foundry core ovens, of baker's ovens, of laundries, or in the warming of large buildings. Fig. 6 illustrates the general arrangement of the furnace. Within a rectangular brick chamber lined with fire-brick are four refractory fire-clay trays or shelves transversely arched, and extending the whole length of the furnace, with the exception of narrow passages left alternately at the back and the front. These slabs rest on supports in the side walls, and are, therefore, easily removable for repairs, without disturbing the structure of the furnaces. Beneath the lowest shelf is a small grate or fireplace, used only in starting the furnace. In the front wall are three doors giving access to the stages and to the grate respectively. In using the furnaces a fire of wood and coke is kept burning in the grate, until the whole of the interior is at a dull red heat; the charge of dust fuel is then introduced, preferably through a hopper in the roof, and is raked down through the end passages from stage to stage, until it is finally spread evenly over the surfaces of the various shelves. An excess of air being admitted, the whole charge rapidly becomes heated, and a slow combustion ensues. The coke fire may now be extinguished, then the air, passing over the stages in alternate directions as it ascends through the passages at back or front, keeps the fuel steadily glowing, and, with the minimum of attention, preserves a perfectly uniform temperature in the products of combustion, which finally make their escape by the channels provided for them. The furnace should be stoked at twelve-hour intervals, though on occasions—as, for example, on Sunday—one charging in the day may suffice; when left for a longer period than twenty-four hours, the temperature is sensibly lowered, and some time will elapse before the normal conditions are restored. Stoking is commenced at the lowest point. With the aid of a long rake inserted through the bottom door, the ash is removed from the pit, and the contents of the lowest stage brought down in its stead; the fuel resting on each of the other trays is then raked on to that next below, beginning at the second lowest; the topmost tray is thus cleared to receive a fresh charge from the hopper. Inasmuch as the breeze, from exposure to the weather, is frequently very wet, it is desirable, as far as practicable, to allow it to dry on the heated furnace top before use; it will then take two days to pass over the four stages of the furnace, and be ultimately removed as a clean ash, containing but a small fraction of combustible matter. Messrs. Donkin have one of these furnaces applied to the heating of a core oven, for which purpose it is very satisfactory; and they have kindly sent up for your inspection samples of the fuel before and after passing over the stages.

FIG. 6.



The inside dimensions of this individual furnace are as follows:—8 ft. in depth by 3 ft. 4 in. in width by 3 ft. 8 in. in height, each of the four working stages, exposing a superficial area of about 21·5 square feet. About 200 lbs. of breeze are added to each charge, showing a total daily consumption of 400 lbs., of which 25 per cent. is subsequently removed as ash.

Wherever possible, as for instance in foundry ovens, the gases on leaving the furnace are led directly into the oven they are intended to heat; but where this is not permissible, as in warming dwellings, they are passed into a chamber wherein they circulate around iron tubes, through which is passed a current of pure cold air. which thus becomes heated and rendered serviceable for warming and ventilation purposes; conversely, if preferred, the furnace gases may pass through the tubes, and the air to be heated around them.

Since the temperature in these furnaces need not greatly exceed the igniting point of the combustible used (indeed, it must never be allowed to reach that at which clinker might be formed, for the clinker would seriously damage the fire-brick arches, and interfere with clean stoking), it will be evident that a fuel highly charged with ash or dirt may be satisfactorily employed. Thus a field for the use of the very poorest material is opened up. Even the sweepings of boiler flues, as above indicated, and the contents of old heaps of slack or breeze, the result of long years of accumulation, may be turned to account. Another distinct advantage is scored in the small amount of wear and tear and depreciation of plant, owing to the comparatively low temperature of the whole furnace.

PERRET'S PATENT PRISMATIC FURNACE.

A later development of this idea has resulted in the introduction of the prismatic furnace, which is intended to burn the same class of fuel, and, in short, to do the same work as the older type, but at a less expenditure of manual labour in stoking. Like the last, this furnace (Figs. 7 and 8) consists of a rectangular brick chamber with a temporary grate beneath; but in lieu of the four stages, there are four tiers of prismatic blocks, of semi-octagonal section, slightly arched longitudinally, and resting base downwards on its end walls. These blocks are so arranged that the spaces between those in one row are immediately above the blocks in the next tier. Beneath each prism there is a passage in the end wall opening from the furnace, and communicating either with the tier beneath or with that above, the communications alternating as in the multiple stage furnace.

FIG. 7.

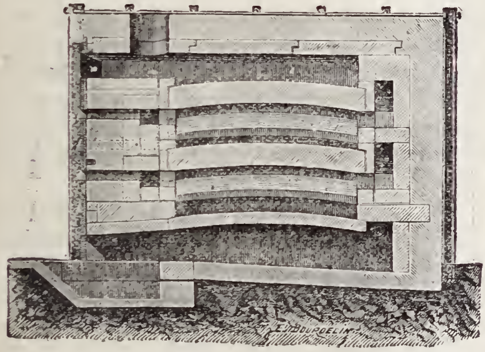
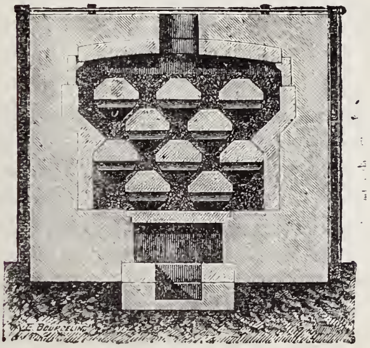


FIG. 8.



In using this furnace, fuel is fed in from above, and passing downwards between the prisms, it fills the whole chamber, with the exception of a free space which forms naturally beneath the entire length of each block. A fire is then lighted in the grate, the heated products of combustion mixed with an excess of air pass through the free spaces beneath the lowest row of blocks, thence ascending through the passages in the end wall, they emerge into the spaces beneath the tier above; here passing in a reverse direction, they again rise to the next row through the channels in the opposite wall, and so on, until at last they reach the top of the chamber. The dust fuel immediately surrounding the sir spaces in the lowest tier becomes gradually ignited, then that surrounding the second row, and the third. At this point the enkindling fire may be extinguished, and combustion will proceed slowly and regularly, requiring attention only at long intervals (12 hours). In stoking, a gentle agitation of the charge surrounding the air spaces beneath the prisms, by means of a rabble, introduced through doors in the furnace front, causes a general subsidence of the upper layers of fuel into the spaces left by the matter which has undergone combustion. This rabbling, which is commenced at the lowest tier, is repeated at each subsequent row, and the operation is completed when the requisite quantity of dust is added from the hopper. The maximum rate of combustion is found to be about 2 lbs. of fuel per hour per square foot of surface of the top row of prisms. The fuel used may be of the worst possible description, the inventor proposing to burn even sawdust and spent tan. Incidentally, it may be interesting to note that, as pyrites-roasting practice led to the adoption of the multiple stage furnace for burning low grade fuels, so it has now been proposed to apply the later, or prismatic form of furnace, to the requirements of the vitriol maker, and recent information from Paris speaks of its successful application in this direction.

GAS-CARBON.

Before concluding, I wish to remind you of a substance which, under certain conditions, makes an admirable fuel. Gas-carbon, or retort-carbon, is a bye-product in the manufacture of coal-gas; it is the carbonaceous matter which, during the distillation, is gradually deposited on the inner walls of the retorts. There is, of course, but a limited supply of this material, which at present is in part broken up and burnt under the retorts, and in part sold for conversion into electric-light carbons; it is, however, a remarkably pure carbon, an analysis of an average sample by Mr. James Paterson showing:—

Carbon	99·38	per cent.
Ash	0·21	,, ,,
Sulphur	0·14	,, ,,
Water	0·27	,, ,,
	100·00	

The mean of several determinations by Thompson's calorimeter gave an evaporative power of 12·57 lbs. of water at 100° C. per 1 lb. of the carbon. The high carbon per-centage indicates a correspondingly high value as a fuel, the unusually small proportion of water marking it out specially for producing high temperatures, whilst the almost entire absence of sulphur assigns to it a special value for experimental work, as it emits practically no sulphurous gases such as are a frequent source of annoyance when coke is employed. We have for a long time used it, alone or mixed with a small percentage of coke, in our large laboratory pot furnaces, which will take crucibles of 100 lbs. capacity, as well as in small experimental blast-furnaces of the Deville type. For the latter purpose especially, we find it to possess great advantages over coke; the absence of ash means absence of fusible clinker, so that the crucible is not slagged down even after very prolonged heating; and, since these furnaces are worked in the open laboratory, albeit under a hood, the freedom from sulphur dioxide in the surrounding atmosphere renders their use far more pleasant than formerly. These remarks apply also, but in a less degree, to the use of the gas carbon in the melting furnaces. I believe that in some districts it is now used for melting brass, and those who have had experience with it will, I think, fully corroborate the statements I have just made as to its cleanliness and sweetness. It is extremely dense and hard; and possessing therefore a high igniting point, it requires a good draught, and must be enkindled in the first place with a less refractory fuel; but when combustion has fairly commenced, it continues to burn steadily and satisfactorily.

Finally, I must express my sincere thanks to several gentlemen for the kind and ready assistance they have afforded me in the preparation of this paper. For the specimens of coal exhibited, this evening, I am indebted to Mr. Proud, of the South Hetton Coal Company.

DISCUSSION.

The **CHAIRMAN** said the importance of this question was very great, for it appeared that in some cases no less than 60 per cent. of the coal got was small, a large proportion being left in the pit as not being worth bringing to bank. Besides this, there was the dust which afterwards arose from handling the coal, and these two items bore a very large proportion to the total amount of coal which would be utilised. Those, therefore, who devised economical methods for using this small coal were doing a national service. Of course, this had a considerable effect on the price of large coal, because if a colliery produced so many tons of large coal, and so many tons of small, and the latter had to be thrown away, the whole of the expenses must be charged a gainst the large, which was thus necessarily enhanced in price. Some attempts had been made to utilise small coal at the pit's mouth by coking, and saving the distillates, and, at one time, great hopes were entertained of this process, but in some places it had to be given up in consequence of the depreciation of the products. Of course, if small coal could be utilised at the pit's mouth, it would be unnecessary to find a method of using it in furnaces; but the failure of this method made it more necessary to find such means. The question of the smoke nuisance had not been referred to, but it had an intimate connection with the question of furnaces. It was very desirable that combustion should be carried on perfectly—not only that all available fuel should be used, but that what was burned should be perfectly consumed, so that no volatile carbon should be sent out from the chimney top. He was sometimes amused to hear complaints of smoke in London, for Londoners did not really know what smoke was, as those who lived in some of the large towns in the North did. Still, even the amount of smoke in London was a just cause of complaint; though, if the air of the manufacturing districts could be rendered as pure as that of the metropolis, a great deal would have been accomplished. He lived in London, and from his house no smoke whatever was sent out; and if everybody would follow his example, the atmosphere would be much purer.

Mr. CRAMPTON said he could not say much on this particular subject, being more acquainted with methods for producing very high temperatures with regularity; with the systems described this was not possible, nor was it required. With regard to the use of powdered fuel, anyone who could discover a means of withstanding the fluxing action of the dirt which was always found in coal-dust would do a great deal; he had burnt some two or three thousand tons of coal in experiments in this direction, but so far without success in being able to retain the furnace for any length of time. The only means of accomplishing it seemed to be to have revolving chambers protected with water; the slag formed a film round the furnace, and thus made a perpetual lining, the surplus slag running away. This form of furnace, however, was only applicable under very special circumstances. He had made some experiments lately, to see how far this method could be applied in steamboats, and he feared it would take up too much room to be convenient, but he was not sure of this. Some dust coal could be utilised by being washed, but this again could only be done profitably in special cases. The water cooled furnace which had been described seemed very ingenious, but he should like to know the quantity of coal which could be burned per foot of grate; this was a most important point, in order to know the grate area required for evaporating a given quantity of water in a certain time. He should think the proportion would be about the same as in Jukes's furnace (but it might be more), which did not burn more than 6 or 7 lbs., or sometimes 8 or 10 lbs. per foot, but the latter quantity was rather trying for the fire-bars. He had seen these furnaces which had been in work for eight years almost without intermission, but it was evident that this could only be accomplished by constant supervision, so as to keep everything in perfect order. In fact, it became a question in many of these furnaces whether they would not require more supervision than could usually be obtained. The prismatic furnace was very ingenious, and he could see by the material produced that a fluxing heat was never attained; the ash could be removed at leisure, but it would probably take a considerable time. In conclusion, he would say that this question could not be brought forward too often; there was a vast amount of coal wasted in this and other countries, and any method by which this could be prevented should be welcomed.

Mr. DONKIN said they could burn about 35 lbs. of coal to the square foot of furnace, with half an inch space, but the average was about 20 lbs.

Mr. HENDERSON said he had no personal connection with the Green furnace, but hearing that Mr. McMillan was preparing this paper, he brought it under his notice as being the one which of all he had seen seemed best to encourage heat, and to admit of the application of the oxygen of the air to the carbon of the coal, so as to ensure perfect combustion and avoid smoke. The furnace was so arranged that the whole of the heat produced on the fire-bars was transmitted to the water underneath, and from there circulated through the boiler; and, apart from the question of combustion, there was this great advantage, that incrustation was prevented. Where incrustation took place, of course it increased the cost of evaporation, and deteriorated the boiler. A few months ago Mr. Green told him that one of these furnaces had been in operation at Swansea for three years, and on examining the boiler at the expiration of that time, the amount of scale found was practically nothing; the iron being almost as clean as the day it was first put in operation. In such a case of course the saving to steam users was very great. He had hoped to hear something on the question of smoke, which depended, as he had already pointed out, on the perfect combination of the oxygen of the air with the carbon of the coal; unless this were effected, a great deal of carbonic oxide was given off. In the colliery districts there was great profligacy in the use of coal, owing to its cheapness, and the amount of small coal wasted was very great and important, especially in large towns. Considering the hard winter we had just passed through, it was a great pity that some method had not been devised by which this small coal could be utilised in the shape of *briquettes*, such as were largely used in France and Belgium. Such a mode of dealing with it would confer a great boon on the poorer classes of our large towns.

Mr. **Crampton** thought the question of carriage would be a great difficulty.

Mr. **Henderson** said there were thousands of tons of small coal almost thrown away in London. In the Pool, where the sea-borne coal was screened, it accumulated in large quantities.

Mr. **Crampton** asked if Mr. McMillan had any information as to the mode of manufacturing these *briquettes* on the Continent. He believed one main difficulty was in getting a simple machine for making them.

Mr. **Jobling** (Messrs. Scott and Co.) said the Ferando furnace had been thoroughly successful in their steamers; they used nothing but "duff," and obtained quite as good results as with large coal; and in one ship rather better, only using 11½ tons of small coal to produce the same result as 12 tons of large. The difficulty of black smoke arose at first, but this had been overcome. There was one steamer now in London, and he should be happy to show the furnace to any one who was interested. The coal they used was the very worst description, costing 2s. 9d. per ton delivered. Two steamers were now running on this system, and arrangements were being made for converting the whole of the fleet, and he expected the plan would soon be generally adopted by steam users.

Mr. **W. Crowder** asked if breeze had been applied for the purpose of raising steam, or only for other heating purposes. There was a good deal of breeze to be obtained in London at a low price, and if it could be used for raising steam it would be a great gain. The furnace appeared to be much on the principle of the Naussig pyrites furnace, such as was used for making vitrol. At his works there were a good many boilers, and the consumption of coal was something considerable.

Mr. **McMillan** said the Perret boiler furnace, which was used by Messrs. Donkin, burned solely breeze, with the water cooled fire-bars. Breeze was also used in the prismatic furnace, but that was only for warming rooms, or for core furnaces. For ordinary boiler furnaces, where a greater heat was required, the water cooled fire-bars were employed; there fresh breeze from gasworks was burned.

Mr. **Arthur Glover** asked if Mr. MacMillan had any information as to the use of breeze or inferior fuel in kilns used for the purpose of making cement, which was now becoming a very large industry on both the Thames and the Medway. Probably over half a million tons of coal per annum were used in this industry, and if this kind of fuel could be used it would save good fuel, and would be economical in every way.

Mr. **W. Crowder** said the lecturer had not made any reference to the Wilson gas producer, which was somewhat similar to some of these furnaces, and would probably throw a light on the last question asked; you could use this low quality fuel for producing gas which would be perfectly available for burning cement.

Mr. **McMillan** said there were so many branches to this subject, and everyone had so many different ideas of his own, that it was very difficult to cover the whole ground. He might have dealt with gas producers, and undoubtedly fuel of this kind might be used in certain classes of gas producers. He had already answered the other questions put, and had only further to thank Mr. Thomson for his kind assistance in preparing the photographs by which the paper had been illustrated.

The **Chairman** then proposed a vote of thanks to Mr. McMillan, which was carried unanimously.

SEVENTEENTH ORDINARY MEETING.

Wednesday, March 31, 1886; the Right Hon Sir **Henry J. Selwin-Ibbetson**, Bart., M.P., in the chair.

The following candidates were proposed for election as members of the Society:—

Bazley, Sir Thomas, Bart., Hatherop Castle, Fairford, Gloucestershire.
Christopher, Robert George, 35, Chauntler-road, Custom-house, Victoria Docks, E.
Harland, Robert Henry, 37, Lombard-street, E.C.
Henderson, John, junr., Meadowside Works, Partick, Glasgow.
Ince, H. Osborne, Eltham-lodge, 193, Kilburn-road, W.
Legg, William A., Liverpool Waterworks, Llanwddyn, Lanfyllin.
Lewis, Henry Frederick William, Lyndham-house, Hampton-road, Redland, Bristol.
Wildy, Augustus G., 13, Furnival's-inn, Holborn, E.C.

The following candidates were balloted for and duly elected members of the Society:—

Dunn, John, 1, John-street, St. James's-square, S.W.
Greenman, Charles, 76, Clayton-road, Peckham, S.E.
Robinson, Edward A., Combe Down, Bath.
Storey, H. S., Lancaster.

The paper read was—

METHODS OF RENDERING THE BLIND SELF-SUPPORTING, ESPECIALLY THAT FOLLOWED IN GERMANY.

By T. R. Armitage, M.D.,
Hon. Sec. to the British and Foreign Blind Association for promoting the education and employment of the blind.

The first time I had the honour to deliver an address at the Society of Arts on the subject of the education and employment of the blind was in 1871. At that time we were just emerging from a period of the greatest confusion in all that related to the education of the blind. Each school used whatever system for reading of which its managers happened to have heard, and once adopted, that particular system was adhered to with the greatest pertinacity. As a rule, each institution worked on its own lines without knowing what was going on in kindred institutions in this country or abroad. It was to put an end to this confusion, and to discover the best methods of educating and employing the blind, that the British and Foreign Blind Association was founded by me in 1868. I was convinced that the only competent judges of questions relating to education through the means of the sense of touch are the blind themselves; and, acting on this conviction, the members of the Executive Council of the Association were all blind with the exception of myself, and my own sight is so imperfect that I am obliged to use the finger, and not the eye, for the purpose of reading, and for the observation of everything requiring exactness. The first question that presented itself to us was the determination of the best system of raised letters for reading, as reading is the basis of all education. We were not, however, satisfied with examining for ourselves, but we took the opinion of all the most intelligent blind within our reach. We found that in all the systems then generally known in England the letters were formed of raised lines. In some of these, the lines represented the ordinary Roman letters, and this form of relief printing was naturally generally favoured by the seeing. The other forms consisted of simple lines, straight and curved, which are far more easily felt than the Roman letter, and were therefore most in favour among the blind. Mr. Conolly, however, one of the earliest members of the council, was one of the very few blind people at that time in England who was acquainted with the admirable system of writing which was used by the blind of France and Belgium. He had, it is true, only a most imperfect writing frame, a clumsy wooden pocket frame, such as was used at that time in Belgium; but even this imperfect apparatus had been of the greatest possible use to him. He had been able to take his notes at lectures, write abstracts of books, &c.; he took an Arts degree at the University of London, and was for years engaged in preparing men for university examinations. It was at once evident that a system by which the blind can write, and easily read what they have written, must be of immense value to them. The only means by which this can be done is by a system composed of raised points in varied positions. Two principal modifications of point systems had to be studied. The one used at that time in France and some other parts of the Continent was invented in 1829 by M. Louis Braille, a blind pupil, afterwards professor, of the Paris School. A modification had been introduced by Dr. Russ, of New York, which was considered by him greatly superior to the original Braille, as he believed that it effected a very considerable saving of space, and could be written more rapidly. It was certain that none of the line systems were suited for educational work, because they could not be written, and the choice therefore lay between the original Braille and its New York modification. It took two years of patient investigation to determine which point system presented the greatest advantages, but the council at last came to a unanimous decision in favour of the Braille system, and set to work to secure its general adoption. In this they have succeeded, and it now would be considered a disgrace for a school for the blind not to teach writing. In fact, writing in relief is of just the same use to the blind as ordinary writing is to the seeing. Having settled the main question of reading and writing, the best method for constructing maps, the best apparatus for arithmetical calculation, &c., had to be determined, but on these points, as on the question of reading and writing, pretty general unanimity now exists. The great aim that should be kept in view in all education for the blind, is to enable them to become self-supporting in after life. With this object great attention should be paid to physical training, as most blind children are naturally weak in body; and the hand should be specially trained, as it is to the hand more than to any other organ that the blind man must look to replace the lost sense of sight.

Kindergarten work and object lessons should form a very important part in the education of blind children, and further training should be all directed to develop the intelligence, strength of body, and dexterity of hand.

Among all callings that the blind can follow, that of music is undoubtedly the best. As tuners, teachers, and organists, the blind, when properly trained, can support themselves very well, and are able to compete successfully with the seeing. In Paris, the blind have almost a monopoly of tuning; and they have obtained this simply because they are found to do their work as well, and in many cases much better, than their seeing competitors. In England, at the time that I delivered my first address in these rooms, it is probable that not more than about 1½ per cent. of the former pupils of our blind institutions were able to earn from £50 to £100 a year by the profession of music; and I then strongly advocated the improvement of the training of the blind in this respect, so that we might achieve here somewhat of the success of the blind in Paris. This idea has since then been carried into practice. The Royal Normal College for the Blind, which was founded soon afterwards, contains now 170 pupils. According to its report, about 80 per cent. of its former pupils are self-supporting, and returns were made in 1884 by 59 former pupils whose aggregate earning for the twelvemonth are stated to have been £6,111. Many who made no returns are known to be doing equally well. For this success to be achieved the pupils have to be placed under the very best possible conditions, and no outlay must be spared to render the general and professional training as perfect as possible. If this is not done, failure will result in the great majority of cases. There are, however, many blind children who are not likely to succeed well as musicians, and the probability of their doing so diminishes if their training is not commenced early; for these, then, some handicraft trade is the most suitable, basket making, rope making, brush making, chair caning, and mat making, and all the varieties of sewing, knitting, &c., for girls, are those trades which are most usually taught. We will now apply the same test to handicraft trades that we did to music, viz., the after success of the pupils. We have no accurate statistics on this subject, but speaking from a very large experience amongst the blind, I should doubt if 10 per cent. of all the former pupils of our institutions can support themselves by the trades they have learnt in schools. Most of the pupils, when they leave, do not attempt to follow the trade that it has taken them six or seven years to learn, but become small traders or pedlars, or turn mangles, &c. When a pupil has been trained in one of our blind schools he is, as a rule, sent out into the world to shift for himself; often before he has completely mastered his trade, without any knowledge of the world, and frequently at a too early age. With such disadvantages, it is no wonder that failure should be common. At most of the Scotch institutions, however, a workshop connected with the school receives the pupil at the end of their training; but even where this is the case it is found that those who attempt to start for themselves almost invariably fail. It is a very serious question whether this most unsatisfactory result is inevitable, and, happily, this question can be answered in the negative. In Germany, a very similar state of things used formerly to prevail, but many years ago a system of careful supervision and assistance of the old pupils was begun in Saxony. It has been gradually perfected by three successive directors, and has been imitated by most of the other German institutions. The result is that over 80 per cent. of the former pupils do succeed in maintaining themselves, by manual trades with the addition, when necessary, of a little systematic assistance from the institution. What makes this fact the more remarkable is that there are scarcely any workshops for the blind in Germany, that nearly all the former pupils work at home. The experience of all those in the United Kingdom who are interested in the employment of the blind, points to the fact that it is much easier for the blind to support themselves when employed in workshops than when working at home; and if it were not for our workshops a much smaller proportion of the former pupils of our blind schools would be self-supporting than at present. In fact, it is our workshops that at present save our schools from the disgrace of the almost universal failure of those pupils who have learnt manual trades, and this is not so much owing to bad teaching as to the utter want of supervision and care of their former pupils. The results in Germany are so different from any with which we are acquainted in England, that the managers of our institutions can hardly believe them, but if true they attribute them to a difference in the social conditions or in the less keen competition which they suppose to exist in Germany. I have known this system for many years, but was somewhat incredulous, until in 1883 I went to Dresden, and spent ten days in going from village to village, and from house to house, visiting the blind workmen, and hearing from their own lips what they were doing. No doubt some of them had a hard struggle, but I found that they were all following the trades they learned when at the institution. The men are all either basket or rope makers, and without exception able to support themselves, though some indifferent workers are obliged to receive assistance from the institution, and this, too, is almost always the case with the women.

The fund for assisting the former pupils amounts to £1,500 a year, and, as their number is about 300, it follows that a supplement, amounting to an average of £5 a year, is all that is required to save everyone from the necessity of receiving parish assistance or begging. The system by which this is done is briefly as follows:—The training in school is always directed to teaching such trades as will be of the greatest use when the pupil leaves school. He never leaves until he has learnt his trade thoroughly, or, at least, as well as his capacity permits. When about to leave, the director visits the locality where the pupil is to settle; arranges his future abode, with his parents or elsewhere, as seems most desirable. He finds some leading person in the district to act as his vicegerent. This is usually a clergyman, doctor, mayor, or some other person of influence; his duties are to give the blind man counsel, whenever necessary; to assist him by recommending him to customers, and to keep the director informed as to his conduct and circumstances. Every former pupil may depend upon the moral and material support of the institution as long as he conducts himself well, does not apply for or receive parish or charitable relief, and works to the best of his or her ability. The pupil is started with an outfit of tools and material, and is helped, if necessary, when suffering from sickness or accident, or whenever an outlay is necessary which is beyond his power to defray.

In England, where no such timely assistance is given, if a blind man meets with an accident, or if there is a temporary cessation of orders, he must manage to live; his clothes, furniture, and tools go to the pawnbrokers, and when once the downward course is commenced it cannot be arrested. One great merit of the system I have been describing is that adequate assistance is given at the right time and in the right manner. I am able to give a very convincing proof that the great success of the former pupils in Germany is due, not so much to better training, or to more favourable conditions of life, as to the admirable system I have been describing. Some years ago, the small States adjoining Saxony sent their blind children to be trained at Dresden. They were educated in all respects like Saxon children, but a marked difference occurred on their return home, for, whereas the pupils from Saxony almost invariably succeeded, those from the smaller States almost invariably failed. Struck with this difference about ten years ago, they established the same kind of supervision which had produced such beneficial results in Saxony, and since this change had been made the results became just as good as in Saxony.

The system is adopted more or less in almost all German institutions. Among these I may mention as good examples, those of Kiel, Neukloster, and the Jewish school at Vienna. These are newer institutions than that at Dresden, consequently there are no pupils who are past work, and almost all, male and female, have no further assistance than a fair start in life, and the privilege of obtaining raw material at cost price, and of sending any work which they cannot dispose of at home for sale at the institution.

A similar society exists in connection with the Paris institution, to find situations and give assistance when necessary to former pupils. Most of these are musicians, and therefore have a better chance of success than those practising manual trades; but many would have failed without being properly started. Several of the provincial institutions of France are establishing a similar system. It is high time that we should do something of the same sort in England; in fact, I do not think there is any reform in institutions for the blind which is so necessary as this.

I am glad that a Royal Commission to inquire into the condition of the blind is now sitting, and it is a pleasure to me to see one of my brother Commissioners in the chair. I hope that the result of our inquiries may tend to the benefit of those to whom for many years I have been devoting my life. I must, however, state that what I have said this evening is entirely unofficial. I alone am answerable for the opinions I have expressed.

DISCUSSION.

Mr. F. J. CAMPBELL, LL.D. (Royal Normal College, Norwood), said he had little to add beyond supporting what Dr. Armitage had said with regard to preparing the blind for independence. On this point he might give one practical illustration. America, some years ago, was far in advance on many points, but some of the American schools had lately rather fallen behindhand, although one or two schools there were as striking examples as that of Dresden. There was a very large school in Philadelphia, one of the oldest in America, yet it was found that a large proportion of those who left it were not self-supporting. Some time since, however, a very energetic and intelligent blind man, and an excellent man of business, resolved that this should not continue, and he undertook singlehanded to establish a working home for the blind. He began with a few inmates, and his first care was to see that they were thoroughly trained, and he found it very difficult at the first to make those who had been in the old schools support themselves; they did not work with determination, but after a time all these men were able to do so. This was entirely due, first, to his good example, and, next, to the very great care he gave to the business part of the concern. There was an outcry amongst the broommakers of Philadelphia that this place was underselling them, and as a State subvention had been applied for to aid in building a shop, and towards the training of the blind, a committee of inquiry was appointed. Mr. Hall, the manager, produced as witnesses some of the largest dealers in Philadelphia and New York, and they gave evidence that for the same class of brooms for which they paid in the ordinary trade 1 dollar 10 cents the dozen, they paid Mr. Hall 1 dollar 5 cents, and found they were better worth the money. This was the key to the whole position; they did good work, and had a good business manager to get it into the market. It took a blind man a long time to learn a trade, the same as it did a sighted man, and Dr. Armitage had made a very true remark about the evil of sending pupils out too early. He had had some experience of that in the Normal College. He had a young man there who, being very poor, was desirous of earning his living as soon as possible; he was trained as a tuner, and was very efficient. Being applied to for a tuner, he (Mr. Campbell) sent this young man, but he had to come back, because his employers said that although he was thoroughly capable, and they had no fault to find with him, there would be a mutiny amongst all the men if such a mere boy were employed at a man's wages, so he must wait until he was older.

Rev. WILLIAM STAINER said this subject was much akin to the one to which most of his life had been devoted, viz., the training of the deaf and dumb, and he had been very much interested in the paper. The great point was to render these people self-supporting, and this question had caused him a deal of anxiety. In his present position, as superintendent of the education of the deaf and dumb under the London School Board, it did not come under his official notice; but he had tried to do something in his private capacity by opening a large home, fitting it up with lathes and tools, and endeavouring to teach the elder boys the use of them. He should like to ask Dr. Armitage if he had any information with regard to day schools for the blind.

Mr. W. C. LESTER (Secretary, Indigent Blind Visiting Society) said there were classes for the blind in various parts of London, and the scholars in them were of all ages, from eight up to eighty. It was very desirable that the young blind should, where possible, be sent to the Board schools, for he was strongly of opinion that the blind should be trained with the seeing, to adapt them, as far as possible, to the same kind of life. He was opposed to the separate system, and felt certain that a young scholar would make much more progress amongst sighted pupils. A great educational work was being done amongst children of a larger growth, and education, during the last fifteen years, had wonderfully progressed. Whereas formerly very few could read, reading was now general; and the Braille system was much in advance of all others, as by it the pupils learned not merely to read but also to write, and to read what they had written; and some forty or more in these classes were employed in writing books for the use of blind persons. He was much pleased with what had been said as to the importance of lending the blind a helping hand at the right time. Some years ago, a blind man came to him, having just left school. He was going to return home, being quite unable to do anything for his support. He (Mr. Lester) promised him a certain amount of help from his society if he could raise £10 from others, and the result was he got together £30. With that sum he started a workshop, got on, was able to employ others, and did exceedingly well.

Mr. CAMPBELL said for many years they had been trying to get blind musicians recognised as real artistes and not simply as blind musicians; in this they had had various encouragements; but one recent one he should like specially to mention. Sometime since he took a pupil to play to Herr Joachim, and after playing pieces of various schools, Bach, Beethoven, Schumann, &c., Mr. Joachim was so much pleased with the pupil that he said he would do anything he could to bring him forward, and on April 10th he was going to play with him at the Saturday Concert.

Mr. SUTTON (hon. secretary Surrey Association for the Welfare of the Blind) had listened with great interest to the paper, but said it was very painful to hear that 90 per cent. of those who left the schools were unable to earn their living. He had met with about half-a-dozen who could earn from 10s. up to 27s. or 28s. per week, but the rest were perfectly incapable. They could use the wood chopper, and do the inferior kind of basket making, and that was all. The reason of this must be deficient training. There were large institutions all over the country, and one large one in London, on the other side of the water, which professed to turn out capable workmen, but he had not found such to be the case. There seemed to be a want of method and intelligence in teaching the kind of work which would be most remunerative. Dr. Armitage had referred to Dresden, but it must be remembered that there the institution was supported by the State, whilst in England they were all dependent on voluntary contributions, and he did not believe there was one institution in England which was supported by the labour of the inmates. There might be individual cases where a man could earn £1 or 25s. a week, but that was only when the institutions provided them with work; competition was so great, even amongst seeing men, that a blind man in a large town would be thrown in the background altogether without some one to assist him. No doubt, in course of time, there would be efficient education for the young, whereby, when they grew older, they would be able to support themselves, but so far there were a very large mass who were more or less dependent. He hoped the difficulty would be in some way met by the labours of the Royal Commission.

Mr. CULSHAW said he was treasurer of the Liverpool School for the Blind, which, with the exception of the one in Paris, was the oldest in the world, and it had the largest number of pupils of any in the kingdom. One point he would refer to was the period spent in the school. Dr. Armitage recommended six years being fixed, but it was very difficult to carry out strictly a rule of that kind. There was an idea amongst the indigent blind that when once they got into an institution they were to stay there all their lives. Some few years since they found there were some of the inmates who had been there thirty or forty years; they were no good to the institution, and they were discharged, though it was painful to have to do so. They then found it was not advisable to fix any definite period, and though it was understood that a pupil who had derived all the advantage he could should not stay longer than six years, as a fact they had some who remained fifteen or twenty years. The committee had the greatest difficulty to find suitable trades for the blind. They had tried brush-making, basket-making, and mat-making for the men only. Dr. Armitage had referred to rope-making, which in Liverpool of course was a most important trade, but after trying it for a long time, they found it did not pay at all. They could not compete with the ordinary traders, and practical people would not come to them. It was much the same with the other trades, and he feared, unless some such system as that adopted in Saxony were followed, there would always be a great difficulty in the majority of the blind maintaining themselves. He knew two or three who had left the institution, and whom he had found in the most helpless state afterwards. They taught music to all who had any aptitude for it; but, in dealing with the indigent blind, it was not advisable to encourage them all to devote themselves to music. They had taught tuning for several years, but it was very exceptional to find anyone in Liverpool who would take a blind person as a tuner.

The CHAIRMAN said at first he had felt some hesitation in accepting the invitation of the Society to take the chair, feeling that he knew too little of the subject individually, and that as one of the Royal Commission which had been appointed to inquire into this matter and take evidence upon the points referred to, it would not be right or proper to express any decided opinion before the Commission had come to a determination on the evidence submitted to it. Still, he thought that without expressing an opinion on any disputed point, he might fairly express the interest he took in a discussion of this kind, the object of which was to increase the public knowledge with regard to our unfortunate fellow subjects, and at all events endeavour to increase that knowledge for their benefit, and with a view to improve their condition. No one could have listened to what had fallen from Dr. Armitage without feeling what a great subject it was, and how far at present England was behind other countries in dealing with it. He trusted that when the time came for the report of the Roya Commission to be issued, it would be seen that they had benefited by the information gathered, not only as to the way in which both the blind and the deaf and dumb were treated in this country, but also by the knowledge which other countries had of this subject, and that out of that knowledge and experience they might be able to suggest something which would be for the benefit of so large and unfortunate a class. He had much pleasure in proposing a vote of thanks to Dr. Armitage for his very able exposition of this subject. No one could have listened to it without feeling that every word he said came not only from his heart but from a long and careful experience, from a life almost devoted to the subject.

The vote of thanks having been carried unanimously,

Dr. ARMITAGE thanked the meeting for the attention they had given him, and said, in reply to Mr. Stainer, that as far as his experience went, good day schools were better than indifferent residential schools, very much better; and as unfortunately there were a good many indifferent residential schools, and the London School Board gave a first-rate education to blind children, he was always glad to see blind children entering day classes, and always recommended them in London, and some large towns where this system was introduced, to enter not only the day classes especially for the blind, but to take their part in the ordinary class education of the school. But, on the other hand, first-rate residential schools were far better than the best day schools could possibly be; for this reason, that day schools, at any rate hitherto, had never attempted to give that careful, individual training which was so essential to the blind child; and most of them did not attempt to give any technical training. Some did, such as the one at Sunderland, and one at Bradford. It was very important that blind children should begin technical training early, and, until this was provided for, they could not do without residential schools for the higher forms of education, music especially, after the preliminaries of the three R's had been overcome. In reply to Mr. Culshaw, he would say that he felt the greatest possible sympathy with gentlemen who, having been educated to see only one phase of this question, had a difficulty in imagining that there was another side to it. The question was not what particular trade should be taught, for if the blind did not succeed in one trade, the school must teach another. The school must teach the trade which was best suited to the blind in after life. The failure lay in two directions. In the first place, schools frequently taught trades which the blind could not follow in after life, such as mat-making, sash-line weaving, and various others. No blind man could succeed in making a living at them, and, therefore, until the whole system of these trades was changed, it was not desirable to teach them at all. Another thing was that very often the particular kind of basket-making was not taught which the blind man would find most useful. What an institution should do was, not to look at what paid best in the institution, but at what would pay best when the blind had left. And when all this was done, nothing was done unless some system were adopted of looking after the blind, similar to that adopted in Germany. That system was hardly known a few years ago by any English institution, and therefore the conclusions arrived at were all arrived at from a treatment diametrically opposed to that which he recommended. He hoped his numerous friends amongst the managers and committees of institutions would forgive him for saying that the system had not been tried at all in England, and that the best thing they could do would be to go to Dresden, Neukloster, Kiel, or any place where this system was fully carried out, and if they did not come back red-hot in favour of it, he should be very much surprised.

FISHERY BOARD.

The proposal to establish a Fisheries Board having been under the consideration of the Council of the Society of Arts, the Secretary wrote on behalf of the Council to Professor Huxley, F.R.S., asking him for his views as to the constitution of the Board, and especially whether he considered it desirable that there should be a representative or representatives of science on the Board. The following is Professor Huxley's memorandum in answer to the Secretary's communication:—

I am of opinion that the less the Government interferes with any branch of industry the better; and that, as a general rule, the cost and trouble of obtaining such scientific information as is necessary for the successful prosecution of a branch of industry ought to fall upon those who profit by it, and not upon the general body of the taxpayers. I do not think that any sane man would propose to establish a Government office, composed of chemists and metallurgists, for the purpose of managing the business of the ironmasters.

The case of the fishing industry, however, is peculiar. The different classes of fishermen tend to encroach on one another's liberties; and, in the case of sea fisheries, the nation at large is proprietor, and has an interest in their being properly worked. Moreover, beyond the three-mile limit, the interests of English fishermen may come into conflict with those of foreigners, and give use to international questions of great difficulty and delicacy. Hence I have no doubt that some department of the Government ought to be in close relation with the fisheries; ought to be able to interfere with them to some extent, and under certain circumstances; and ought to be able to institute or undertake such scientific inquiries as may be needful in order to obtain satisfactory data for its action.

My first connection with fishery questions dates back now about a quarter of a century; and, from that time to this, I have taken every opportunity of urging the formation of a Government Department, such as I imagine is now about to be established, empowered to deal with the fisheries on these principles.

I think that such a Fishery Department should—

1. Collect accurate statistical and other information respecting the fisheries of England, bearing upon fishery interests in general, and present a yearly report to be laid before Parliament based thereupon.

2. That it should be empowered to inquire into grievances of fishermen, and suggestions for improvement of the fisheries. Hitherto the only method open to those who were, or supposed themselves to be aggrieved, was to get a Royal Commission of Inquiry appointed. Within my experience, three of

these Commissions have inquired at intervals of eight or nine years, at great cost of trouble and money, into the same questions regarding the sea fisheries, and have arrived at practically the same results.

3. That it should have power of inquiry to make orders regulating or restricting acts of fishery.

4. That it should be empowered to obtain such scientific assistance as may be needful.

It is to this last point that the questions addressed to me are more particularly directed; but I could hardly have answered them satisfactorily, unless I had sketched forth my general views as to the justification and the limits of State interference in fishery matters. I have had something to do both with science and with administration; and it is in the interest of both that I express my strong conviction that they ought to be kept separate.

The function of the man of science is to ascertain facts, and give advice based upon that which he has ascertained. He may be the most competent person in the world to do that, and, at the same time, wholly unfit for administrative duties. If, again, we consider the four kinds of action to which, I believe, the operations of a Fishery Department should be restricted, what is the advantage of setting a skilled naturalist to collect and digest statistics, or to draw up regulations and orders, or to weary out his soul in the routine business of an administrative office? What he is wanted for is to act, firstly, as an assessor in inquiries; and, secondly, as an investigator of such problems as bear directly upon those fishery questions in which the general public is interested. For example, the nation at large has an interest in providing against the practice of unduly wasteful modes of fishing, as tending to the wanton destruction of its property; and I should say that any amount of money bestowed upon the scientific investigation of the effect of some modes of fishing might be well spent.

I am strongly of opinion that the best method of bringing science into its proper relation with the Fishery Department is, that the latter, when it requires a scientific answer for an inquiry, or when it desires that a scientific problem should be thoroughly investigated, should apply to the President and Council of the Royal Society to nominate a person or persons to undertake the work. That is a course frequently pursued by other Governmental departments, and it works very satisfactorily. However, if it should be thought better to have a permanent adviser, or a permanent committee of reference, I see no great objection to the adoption of either of these plans.

But what I desire to repudiate as strongly as possible, in the name and the interests of science, no less than in that of the working fishermen, is the proposal which I see continually pressed in letters addressed to the papers, to appoint a body of scientific men to "manage" the fisheries. In the first place, the proposition is futile, for anybody who knows anything about the feeling among the smack owners and working fishermen, is aware that they would not listen to such a proposal for a moment. In the second place, the notion that the fisheries want "managing" by a Government office, and that the fishing business, like every other, ought not, as far as possible, to be left to manage itself, is, in my opinion, utterly foolish and mischievous. And, in the third place, if the fisheries were to be thus "managed," men of science are no more the right people to be entrusted with "managing" fishery affairs than a landsman, who happens to be master of the theory of navigation, is the right man to be trusted with steering an ironclad.

The whole lesson of my somewhat lengthy and varied experience of fishery matters may be summed up thus:—

1. Don't meddle, unless you have good grounds for believing that you know what the effect of your meddling will be.

2. Listen to all that the scientific men without practical knowledge, and the practical men without scientific knowledge, have to say; but give to neither the power of directly interfering with such a large and important branch of industry as fishing.

3. Collect all the information that is to be had, so that the country may know year by year how the fisheries really stand; make that information accessible to the people who are engaged in the fishing industry; inquire into real or supposed grievances; and regulate or restrict, experimentally, on good cause shown.

4. Let the Department charged with these duties obtain such scientific help as is needful from persons of recognised scientific competency, who are not under the control of the Administrative Department, and are not responsible to anyone for the conclusions at which they may arrive. Moreover, let all scientific inquiries thus undertaken be strictly relevant not merely to fishery matters, but to

questions with which the State may properly deal as the representative of the general interest.

If the Government is to be asked to give a body of scientific men a roving commission to inquire into the natural history of the seas and rivers of England, let that issue be put plainly before the Minister to whom the application is made. But I do not see what the Board of Trade has to do with such "aid to science;" nor why it is desirable that the gentlemen who are to be entrusted with this very considerable enterprise should have the "management of the fisheries"—which means the power of meddling with a great industrial interest—thrown in as a sort of *hors d'œuvre*.

T. H. HUXLEY.

March 20, 1886.

Miscellaneous.

COLONIAL AND INDIAN EXHIBITION.

Her Majesty the Queen has been graciously pleased to intimate her intention of opening the Exhibition, on Tuesday, the 4th of May; and an additional impetus has thus been given to the work of preparation which is actively proceeding.

The change in the weather has materially facilitated the building operations, which had been somewhat delayed by the severe frost; and a marked advance has been lately made in all structural alterations. A constant supply of exhibits still continues to reach the Exhibition from all sources.

On Monday last (March 29th), H.R.H. the Prince of Wales visited the Exhibition. His Royal Highness, accompanied by H.R.H. the Duke of Connaught, a Royal Commissioner, was received by Sir Philip Cunliffe-Owen at the main entrance in Exhibition-road. Their Royal Highnesses, conducted by Sir Philip, went through the courts of India, the West Indies, Hong Kong, Canada, New Zealand and the Australian colonies. Sir Dighton Probyn, Colonel Ellis, Mr. Francis Knollys, and Major Egerton were in attendance.

Mr. J. Adrien Despeissis, the Executive Commissioner for Mauritius; Mr. B. Howell Jones, Executive Commissioner for British Guiana; Mr. F. A. Swettenham, the Executive Commissioner for the Straits Settlements; and Mr. Alpin F. Thomson, of the Western Australian Commission, are now in London.

The West Indian, British Honduras, and Hong Kong courts, situated in the East Gallery, are amongst the most forward in the Exhibition; the following notes point out a few of their special features.

WEST INDIES.

Mr. Augustus J. Adderley, C.M.G. (who was Executive Commissioner for the Bahamas at the International Fisheries Exhibition) is Executive Commissioner for the many islands which together form the British West Indies: Major Malet acts as Secretary.

For the purposes of the Exhibition, the islands have been grouped as follows:—Jamaica, Trinidad, Barbados, Windward Islands, Leeward Islands and the Bahamas. In every island a committee has been appointed, and the lists of them occupy no less than ten pages in the official prospectus. In several of the principal towns exhibitions have been held for the purpose of selecting objects to represent the various islands.

The courts—as in the East Indian gallery—are entered through screens decorated in a Moorish style, which recalls the supremacy once held by Spain in the West Indies.

Amongst the principal exhibits will be sugar canes and sugars of all kinds; coffees and cocoas; dried fruits and honey; rums and liqueurs; pink pearls, corals, shells, sponges and minerals. The court will be embellished with fine palms, pine-apples and bamboos from Antigua, cabbage palms from St. Kitt's, lime-trees from Montserrat, and tree-ferns from Dominica.

The Pope and the Propaganda College have consented to lend very valuable and interesting maps of the islands, amongst which will be a *fac-simile* copy of the famous Borgia map, the oldest existing chart of the New World. There will be stone implements and other relics of the now extinct Carib race; and many paintings of landscapes, flowers and insects. In fact, the miniature picture gallery will be quite a feature in the court. Views of various towns have been introduced into the frieze of the wall decorations.

A statue of Columbus, by Signor Ghidoni, of Milan, and relics of the great discoverer will have a prominent place in the gallery, in which also stands a fountain in Doulton ware, designed by Mr. Tinworth.

In a special tank, now being constructed in the Aquarium Annexe, the process of hatching marine turtles from ova will be publicly demonstrated; and arrangements have been made for the preparation of turtle soup and other appetising dishes. There will also be a constant supply of fruits and vegetables for the Colonial market.

The band of the 1st Native West Indian Regiment is coming over from Jamaica, and will play daily in the Exhibition during the season; their picturesque uniform is very like that of the Zouaves.

BRITISH HONDURAS.

Mr. Adderley is also Executive Commissioner for British Honduras; the Assistant Commissioner is

Chief-Justice W. A. M. Sheriff. The local commission at Belize has sent over to England the articles exhibited by them at the New Orleans Exhibition. The principal exhibits will be woods, stone implments, pre-historic pottery, ancient Aztec curiosities, and many other interesting objects.

HONG KONG.

The Secretary to the Royal Commission is Executive Commissioner for Hong Kong, and the court is being arranged, under his direction, by Mr. H. E. Wodehouse, Honorary Secretary to the Commission at Hong Kong, and Mr. E. H. Fishbourne, LL.B., The Honourable William Keswick, M.L.C., is chairman of the local commission, which consists of thirty-five members—native and European.

There will be a very good collection of models, consisting of the docks at Hong Kong; a vermilion factory; junks; a joss-house; a theatre; a convent, with pagoda; a dispensary, accompanied by medicines; and a raised map of the colony, surrounded by photographic views. There will be a bamboo yard, with bamboo workers, and chairs and other articles of bamboo and rattan; a mat-making machine; a shop and a hawker's stall; blackwood furniture, sedan chairs, a *janricksha*; and a trophy of china. A 20 horse-power engine, built by the Dock Company, will also be placed in the court.

The trade of the colony will be further represented by ropes; brass, pewter, tin and silver ware; pith hats and shoes; biscuits; an opium pan and stove; butterflies, coins, woods, granite, spirits, oils; ginger and chow chow; sugar and molasses; an exhibit of silk; and examples of needle-work from the convents.

ELECTRIC LIGHTING.

The electric lighting is under the control of a committee composed of Sir Frederick Abel, chairman; Sir Francis Bolton, who directs the garden illuminations; and Mr. W. H. Preece, who specially looks after the lighting of the buildings.

The whole of the motive power required for the internal lighting of the exhibition buildings will be supplied under contract by Messrs. Davey, Paxman and Co., of Colchester; the power absorbed amounts to 1,200 indicated horse-power.

The principal galleries and courts will be lighted by arc lamps, of which 160 are supplied by the Anglo-American Brush Electric Light Corporation, Limited; 140 by Messrs. R. E. Crompton and Co.; and 100 by the Pilsen-Jöel Electric Light Company, Limited —making 400 lamps in all, each lamp giving a light equal to at least 1,000 standard candles.

The Indian Palace, the dining-rooms, and the different offices in the "Old London-street" (or "The Old London World's Exchange" as it is to be called this year), as well as the Colonial and Indian tea houses, will be lighted by means of incandescent lamps, supplied with current by the Edison-Hopkinson dynamo machines. These machines are lent by the Edison-Swan United Electric Light Company, Limited.

The club dining-rooms, over the West Arcade; the Chinese Pavilion; the Royal Box, underneath the clock tower; the secretarial offices, and the Subway to the South Kensington Station, will be lighted by incandescent lamps, which are fed by secondary batteries, lent by the Electrical Power Storage Company, Limited. These secondary batteries will be charged by Edison-Hopkinson dynamo machines.

The electric illumination of the gardens will be effected by means of about 10,000 small glow lamps (mostly of 10 candle-power each); and, in addition, a number of arc lamps suspended from tall masts will be used to give a strong moon-like effect, when the illuminated fountains are not playing. This installation, as well as the whole of the work connected with the fountains, which have been enlarged and altered, has been carried out by Messrs. Galloway and Sons, of Knott Mill Iron Works, Manchester.

REMOVAL OF SNOW.

So heavy a fall of snow as that at the beginning of the present year has not been known in the Belgian Ardennes for a period of thirty years. The highest hedges disappeared, and in some places the snow drifted to a height of 4 metres, or 13 feet. The postal service was interrupted, and it became necessary to dig out a train on the Gouvy and Bastogne line. So late, again, as the 5th March, the snow fell at Laroche to such an extent that the postal service was made with difficulty by horsemen, causing some delay. The dilligence between Baconfoy and Marloie was obliged to stop running; at the "Baraque de Farture" the snow drifted to a depth of 3 metres, or 10 feet. Snow which fell in Paris, on the 8th and 10th December, to a depth of about 4 inches, was removed at a cost of 220,000 francs, or £8,800, by means of salt, which has the property of forming with snow a liquid mud that can only freeze at a very low temperature. The method, devised by M. D'Ussel, engineer to the Paris Municipality, was first adopted in the winter of 1880-1. Rock salt, obtained from salt mines in the east of France, costing about 37 francs., or 25s. a ton, at Paris, is kept in large storehouses until required for distribution in different quarters of the City at the beginning of winter. Directly any considerable fall occurs, the scavengers bring salt in wheelbarrows, and throw it over the surface of the fallen snow; but no effect is produced until the snow and salt are churned together by the horses' hoofs and wheels of vehicles. After two or three hours, however, liquefaction is sufficiently advanced for the clearance to be effected by sweeping machines or brooms. On an average, the quantity required is 125 grammes per square metre, or 2 lbs. per square yard, the cost of the salt amounting to rather less than an eighth of the whole expense, which is three or four centimes per square metre, or about a farthing per square yard. It appears that this method is not applicable to macadamised roads, because the salt disintegrates the roadway.

CULTIVATION OF IXTLE IN MEXICO.

The ixtle, or Tampico fibre, is stout, cylindriform, and of the strongest descriptions of fibre known. It has a yellowish-white colour, and varies in length from one to three feet, according to localities where the plant grows. The fibre designated as *tula* measures an average length of 24 inches, and the *yanmave* averages 30 inches. Consul Cassard, of Tampico, states that the ixtle is extracted from the leaf of the *Agaves Mexicana*, to which species belongs the *maguey*, or aloe, and much resembles the latter in the form and conditions of growth, although smaller in size. It has an elongated, sharp, thorn-edged leaf, containing about three parts of aqueous matter, and one part of solid, which is all fibre. On maturing, the ixtle shoots up from its very centre a long round flower-stem, which, on attaining its full growth, falls to the ground, carried by its own weight. The special botanical name, Consul Cassard says, is not known in Mexico. Ixtle is its Indian name, and the Spaniards have given it the local appellation of *Lechuguilla*. It grows wild in the stony sections of the table lands of the States of Tamaulipas and San Luis Potosi, and its most extensive fields lie in the vicinity of the towns of Tula and Yanmave. Growing with extraordinary luxuriance, in inexhaustible fields, it it is never replanted, and the cropped fields lie in barrenness with but a few isolated leaves growing sparsely from the old roots. To become an article of commerce, the ixtle is submitted to a very simple process of curing, which consists in completely purging from its leaf the watery matter, and then in exposing to the sun the cleansed fibres, which are thus dried and bleached. The contrivance used in curing the leaf is very primitive, consisting simply of a triangular smooth edged piece of iron, measuring about sixteen inches long and two inches broad, with a handle at one end and a hook at the other. A board is laid at the foot of a tree, and over it crosswise is placed the iron or presser, one end hooked on to the roots of the tree, and the handle end resting in the operator's hand, with which he strongly presses the leaf against the board, while with the left hand he draws it its full length, repeating the operation until the leaf is completely purged of its aqueous matter. By the above process an Indian is enabled to clean on an average twenty pounds of ixtle per day. The cutting and curing of the leaves have no special season; both these operations are performed while the plants ripen, and this occurs throughout the whole year. A large trade is carried on in the export of ixtle from Mexico. From the port of Tampico alone about 7,000,000 pounds are annually shipped to Europe and the United States.

Correspondence.

LIGHTHOUSE ILLUMINANTS.

It is, I suppose, not desirable that I should remain absolutely silent on the subject of Mr. Wigham's letter in the last number of the *Journal*, lest judgment against me should go by default.

But really there is little or nothing to answer, because all the points raised by Mr. Wigham are discussed in my paper. If any readers of the *Journal* are induced to think that I have been unfair or generally inaccurate, I would ask them to do me the justice to read my paper through carefully, and they will find all the points referred to in Mr. Wigham's letter fully dealt with.

E. Price Edwards.

30th March, 1886.

AFGHAN FRONTIER.

I have just read with great interest Mr. Simpson's paper on his "Experiences on the Afghan Frontier." Will you kindly permit me to add a word of additional testimony to the "blessedness" of Badghis (p. 489) to which he refers?

Of late years it has been the fashion (I think since M. Lessar's first visit to these parts) to call a part of the Paropamisus by the name of "Barkhut." I tried when I was down in those regions to find any warrant for this name as so applied, but could find none. It was not known by any one across whom I came. But one day a native, in discussing with me the fruitfulness of the soil, remarked that the hills were a "Kuh-i-Barakat" mountain (full of) blessing. Here methought is the derivation, and this idea was confirmed by my friend Major the Hon. M. Talbot, who just about the same time was struck by the same phrase used to him by a Dervish.

Alexander Finn.

Peamore, Torquay,
March 29th, 1886.

General Notes.

Prevention of Fire-damp Explosions.—The Austrian Government offers a prize of a thousand florins (or about £85) for a discovery or invention affording the best means for preventing fire-damp explosions in collieries. The method employed must absolutely prevent all contact of explosive gas with inflammable matter; must not provoke the disengagement of deleterious gases other than those now known; must be simple, and present no cause of danger; be of rapid and not complicated application; and not exceed in cost the methods hitherto employed. Application is to be made to the Imperial Direction of Mines, Vienna, before the 1st of January, 1887, accompanied by an officially attested report of the result of actual trials. The discovery to which the prize is awarded will remain the property of the inventor, who must make known his name and address.

MEETINGS OF THE SOCIETY.

ORDINARY MEETINGS.

Wednesday evenings, at Eight o'clock:—

April 7.—"Preparation of Drawings for Photographic Re-production." By J. S. Hodson. Lord Alfred S. Churchill will preside.

April 14.—"The Treatment of Sewage." By Dr. C. Meymott Tidy. Sir Frederick Abel, D.C.L., C.B., F.R.S., will preside.

FOREIGN AND COLONIAL SECTION.

Tuesday evenings, at Eight o'clock:—

April 13.—"The Progress of the British Possessions in the last quarter of a century." By P. L. Simmonds.

May 6.—"The Commerce and Industries of New South Wales." By Edward Combes, C.M.G., President of the Board of Technical Education of New South Wales. Sir Henry Barkly, G.C.M.G., K.C.B., F.R S., will preside.

APPLIED CHEMISTRY AND PHYSICS SECTION

Thursday evenings, at Eight o'clock:—

April 8.—"Asbestos and its Applications." By James Boyd. Sir Frederick Abel, D.C.L., C.B., F.R.S., will preside.

May 13.—"The Scientific Development of the Coal Tar Colour Industry." By Professor R. Meldola, F.C.S.

INDIAN SECTION.

Friday evenings, at Eight o'clock:—

April 2.—"The History of Archæology in India." By James Gibbs, C.S.I., C.I.E., late Member of the Viceroy's Council. Sir George Birdwood, M.D., C.S.I., Member of the Council, will preside.

May 7.—"Indian Manufactures from a Practical Point of View." By B. H. Baden Powell, C.I.E. The Right Hon. Lord Harris will preside.

May 21.—"Everyday Life of Indian Women, as revealed in their own sayings." By Capt. Richard Carnac Temple.

The above dates are liable to alteration.

CANTOR LECTURES.

The Fifth Course will be on "The Arts of Tapestry Making and Embroidery." By Alan S. Cole.

Lecture I.—April 5.—Points of resemblance between Weaving, Tapestry-making and Embroidery—Special technical peculiarities of each process—Ornamental effects as characteristics common to Decorative Textiles—National Styles—Works by Cavemen and Eskimos—Types of Cosmopolitan Ornamental Devices—Coincident similarity between Ornaments produced by different people at various periods—Imitation as a factor in production of Ornament—Leochare's group of Ganymede and Eagle compared with similar compositions in Sassanian Metal Work and Græco-Buddhist Sculpture—Deterioration from, and aspiration to, a given standard of performance in Drawing and Composition—Types of New Zealand Ornament—Types of Scandinavian Ornament—Résumé.

Lecture II.—April 12.—Classical allusions to Decorated Hangings—Method of making Tapestries compared with that of simple Weaving and Carpet-making—Textiles of Græco-Egyptian, Turcoman, modern Japanese—Indications of Commerce, Craft-Gilds, and organised Factors during 1st to 12th Centuries in Europe, Syria, Persia—Application of the Tapestry-making Process to Hangings—Antiquity of use of Hangings—Decorated Textiles used in 11th and 12th Centuries—Bayeux Tapestry—Tapestry from St. Gereon, at Cologne—Scheme of its Pattern compared with that shown in Sassanian Metal-work—Sicilian Weavings—Italian and Icelandic Embroideries—Early mentions of Tapicers and Tapissiers—Patronage of the Burgundian Dukes—Influence of Flemish Paintings upon Designs in 14th and 15th Centuries—Spread of Tapestry-making in other European Countries—Petrarch's Triumphs in Books, Furniture, and Tapestries of the late 15th and 16th Centuries—Tapestries in 17th Century—Gobelin's—Mortlake—Résumé.

Lecture III.—April 19.—Embroidery—Two Classes: Embroidery on one side of a material; on both sides—Indications of wide-spread use of Embroidery, and same form of stitches—Long practice of the Art by Mohammedans, Chinese and Japanese—Influence of Christian Ecclesiastical Establishments in developing Embroidery, and Designs for it, in Europe—Importance of considering Embroideries in respect of their workmanship and design—Analysis of Stitches—Simplicity of classification—The numerous names given to works of technical similarity—Specimens of Embroideries of different times in respect of Articles of Use and Costumes—Résumé.

ADDITIONAL LECTURES.

Six Elementary Lectures on "Electricity" will be delivered by Professor George Forbes, on Saturday afternoons, at Three o'clock:—

Lecture I.—April 3.—Electromotive Force and Potential.

Lecture II.—April 10.—Currents and Resistance.

Lecture III.—May 1.—Magnetism.

Lecture VI.—May 8.—Electro-magnetic Phenomena.

Lecture V.—May 15.—Induction.

Lecture VI.—May 22.—Electrical Measurement.

Tuesday evenings, at Eight o'clock :—

"Japanese Art Work." BY ERNEST HART.

Lecture I.—May 4.—Japanese Metal Work.

Lecture II.—May 11.—Japanese Porcelain and Pottery.

Lecture III.—May 18.—Japanese Picture Books and Drawings.

The rules of admission to these Lectures will be the same as for the Cantor Lectures. Each member has the right of admission for himself and one friend.

Tickets available for all the Society's meetings were supplied to all the members at the commencement of the Session.

MEETINGS FOR THE ENSUING WEEK.

MONDAY, APRIL 5...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. (Cantor Lectures.) Mr. Alan S. Cole, "The Arts of Tapestry-making and Embroidery." (Lecture I.)

Farmers' Club, Salisbury Hotel, Salisbury-square, E.C., 4 p m. Mr. James Howard, "Haymaking."

Engineers, Westminster Town-hall, S.W., 7½ p.m. Mr. Arthur Rigg, "Obscure Effects of Reciprocation in High Speed Steam-engines."

Chemical Industry (London Section). Special Meeting in the Lecture Theatre, City and Guilds of London Institute, Exhibition-road, S.W., 8 p.m. Prof. Unwin, "The Principles and Methods of Testing Cementing Materials."

Medical, 11, Chandos-street, W., 8½ p.m.

Victoria Institute, 7, Adelphi-terrace, W.C., 8 p.m. Paper by Prof. Hull.

TUESDAY, APRIL 6...Royal Institution, Albemarle-street, W., 3 p.m. Prof. A. Gamgee, "New Function of Circulation." (Lecture V.)

Central Chamber of Agriculture (at the HOUSE OF THE SOCIETY OF ARTS), 11 a.m.

Civil Engineers, 25, Great George-street, S.W., 8 p.m. Mr. Percy F. Frankland, "Water-Purification; its Biological and Chemical Basis."

Pathological, 53, Berners-street, Oxford-street, W., 8½ p.m.

Biblical Archæology, 9, Conduit-street, W., 8 p.m.

Zoological, 11, Hanover-square, W., 8½ p.m. 1. Mr. F. E. Beddard, "Some Points in the Anatomy of *Chauna chavaria*." 2. Miss Agnes Crane, "A Brachiopod of the Genus *Atretia*." 3. Mr. J. G. Goodchild, "The Disposition of the Cubital Coverts in Birds."

WEDNESDAY, APRIL 7...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. Mr. J. S. Hodson, "Preparation of Drawings for Photographic Reproduction."

Geological, Burlington-house, W., 8 p.m. 1. Mr. G. W. Lamplugh, "Glacial Shell-beds in British Columbia." 2. Mr. James Backhouse, "A lower jaw of *Machairodus* from the 'Forest-bed,' Kessingland." 3. Mr. E. Tulley Newton, "A contribution to the History of the Cetacea of the Norfolk 'Forest-bed.'"

Royal Society of Literature, 21, De la Hay-street, S.W., 8 p.m.

Archæological Association, 32, Sackville-street, W., 8 p m. 1. Rev. J. J. Daniell, "Prehistoric Enclosure on Langley Burrell-common." 2. Mr. Thos. Morgan, "Notes on a Roman Monument at Piersbridge, Durham."

Obstetrical, 53, Berners-street, 8 p.m.

Civil and Mechanical Engineers, 7, Westminster-chambers, S.W., 7 p.m. Mr. A. Ivor Smith, "The Working and Interlocking of Railway Signals, &c., by Electricity."

THURSDAY, APRIL 8...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m (Chemical and Physical Section.) Mr. James Boyd, "Asbestos and its Applications."

Royal, Burlington-house, W., 4½ p.m.

Antiquaries, Burlington-house, W., 8½ p m.

College of Physicians, Pall-mall East, S.W., 5 p.m. (Lumleian Lectures.) Dr. W. H. Stone, "The Electrical Conditions of the Human Body." (Lecture I.)

Royal Institution, Albemarle-street, W., 8 p.m. Prof. Dewar, "Electro-Chemistry." (Lecture III.)

Telegraphic Engineers and Electricians, 25, Great George-street, S.W., 8 p.m. Adjourned discussion on Mr. Alexander Bernstein's paper, "Electric Lighting by means of Low Resistance Glow Lamps."

Mathematical, 22, Albermarle-street, W., 8 p.m.

FRIDAY, APRIL 9... United Service Institute, Whitehall-yard, 3 p m. Major J. T. Bucknill, "Personnel for Submarine Mining."

Royal Institution, Albemarle-street, W., 8 p.m. Weekly Meeting, 9 p.m. Mr. W. Anderson, "New Application of the Properties of Cork to the Arts."

Astronomical, Burlington-house, W., 8 p.m.

Civil Engineers, 25, Great George-street, S.W., 7½ p.m. (Students' Meeting.) Mr. Gilbert M. Hunter, "Locomotive Engine and Carriage-sheds, as used on the Caledonian Railway."

Quekett Microscopical Club, University College, W.C., 8 p.m.

Clinical, 53, Berners-street, W., 8½ p.m.

New Shakspere, University College, W.C. 8 p.m. Mr. R. Boyle, "The Plays which Fletcher wrote with other Dramatists."

SATURDAY, APRIL 10...SOCIETY OF ARTS, John-street, Adelphi, W.C., 3 p.m. (Special Lecture.) Prof. George Forbes, "Electricity." (Lecture II, "Currents and Resistance.")

Physical Science Schools, South Kensington, S.W., 3 p.m. Professor Balfour Stewart, "The Causes of Diurnal Changes of Terrestrial Magnetism."

Royal Institution, Albemarle-street, W., 8 p.m. Professor Oliver Lodge, "Fuel and Smoke." (Lecture I.)

Geologists' Association, 2½ p.m. Visit to the Science Collection, South Kensington, under the direction of Professor Judd.

CORRECTION.—In Mr. Vincent Robinson's paper (see *ante* p. 452, col. 1, line 13), the cheap substitute for *kermes* should be *lac*, not, as printed, *cochineal.*

Journal of the Society of Arts.

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FRIDAY, APRIL 9, 1886.

All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

NOTICES.

CANTOR LECTURES.

The first lecture of the fifth course on "The Arts of Tapestry Making and Embroidery," was delivered by Mr. Alan S. Cole, on Monday evening, 5th inst. The lecturer dealt more especially with the growth of design, and the coincident similarity between ornaments produced by different people at various periods. He drew attention to the points of resemblance between weaving, tapestry-making, and embroidery, and illustrated the different classes of ornament, such as the spiral, the key pattern, &c., as they occur in widely separated periods, and in different nations, by a series of lantern slides thrown on the screen by means of the electric light.

The lectures will be printed in the *Journal* during the summer recess.

WESTGARTH ESSAYS.

The three essays by W. Woodward, H. H. Bridgman, and J. Corbett, to which the prizes offered by Mr. William Westgarth were awarded by the Society of Arts in 1885, are now published under the title of "Essays on the Street Re-alignment, Re-construction, and Sanitation of Central London, and on the Re-housing of the Poorer Classes." The volume is published by George Bell and Sons at 15s., but copies can be obtained by members of the Society of Arts for 10s. each, on application to the Secretary.

Proceedings of the Society.

INDIAN SECTION.

Friday, April 2, 1886; Sir George Birdwood, M.D., C.S.I., in the chair.

The Chairman, in introducing the reader of the paper, observed that Mr. James Gibbs was a most distinguished member of the Indian Civil Service, who had held some of the highest offices of State in India. He was in Scinde as Assistant Judicial Commissioner, and Acting Assistant Political Commissioner, at Sir Bartle Frere's right hand, all through the trying period of the Mutiny. Subsequently he was for ten years a judge of the High Court of Bombay, and, afterwards, for five years a member of the Government of Bombay, and for five years more, ending last May, a member of the Legislative Council of India. From the beginning of his career Mr. Gibbs had been an assiduous and zealous student of the general archæology, and particularly of the numismatology of India. He was, in fact, the founder of the Archæological Survey of Western India, which had for years past been so admirably conducted by Dr. James Burgess, C.I.E., who had now succeeded General Cunningham as Director-General of the Archæological Survey of India. Mr. Gibbs could, therefore, speak with authority on the subject of his paper, which, as an index to the progress of Indian Archæology, would form a valuable addition to the records of the Society of Arts.

The paper read was—

THE HISTORY OF ARCHÆOLOGY IN INDIA.

By James Gibbs, C.S.I., C.I.E.
Late Member of the Councils of the Governor of Bombay and the Governor-General of India.

The archæology of India has of late years been brought much more prominently before the public than it was formerly. But although from time to time notices of what was being done have appeared in the form of published reports and occasional paragraphs in the public press, no full and connected account has yet been put forward, from which those interested in the subject could obtain any correct idea of the extent or value of what has been really done.

Having been for many years deeply interested in the antiquities of India, especially its coins and the preservation of its ancient monuments, and having been officially connected with the

Department of Archæology, both while a member of the Bombay Government as well as that of India, I have, at the request of some friends, consented to give a short account of what has been done towards collecting information about India and its people, their manners and customs and early history, as well as the survey, illustration, and conservation of its ancient monuments. I do this the more willingly as I know the British Government has been at times censured by foreign *savants* for neglecting its duty in this respect. This may have been to some extent a just charge in former years, but latterly the subject has been made a branch of the general administration of the country, and no slur can now be cast on us for not taking care of the treasures which have come into our charge.

In the earlier portion of this paper I shall use the term "archæology" in its wider sense, restricting it to what it is more generally confined, viz., the history of ancient buildings, in the later part of my observations.

I will commence by alluding to the earliest steps taken in regard to this interesting subject, and I may, perhaps, take the foundation of the Asiatic Society of Bengal as the starting point. This society, which held its centenary meeting on the 15th January, 1884, at which I had the pleasure of being present, was established at the suggestion of Sir William Jones, a judge of the Supreme Court of Judicature, and has during the century of its existence done much to carry out the object for which it was founded, and which was stated to be "to inquire into the history and antiquities, arts, sciences, and literature of Asia;" and its founder, in his inaugural address, when enlarging on the details of such inquiries, said, "if now it be asked what are the intended objects of our inquiries within these spacious limits, we answer man and nature; whatever is performed by the one or produced by the other"—which is now paraphrased on all the society's publications thus, "The bounds of its investigations will be the geographical limits of Asia, and within these limits its inquiries will be extended to whatever is performed by man or produced by nature."

Its bead-roll contains many well known names. To enumerate a few—we find those of Sir William Jones, the founder and first president, one of the earliest Englishmen who undertook, by translations, to place within the reach of European scholars the wisdom and science which is found in the ancient MSS. of Hindoo sages. Henry Thomas Colebrooke, who after serving the society in various offices, ending in that of president, returned to England, and was one of those who founded the Royal Asiatic Society of Great Britain and Ireland. He was a profound Sanskrit scholar, and his papers are still, in spite of the great advance which has of modern times been made in Oriental research, looked upon as models of their kind. Sir Charles Wilkins, the first Englishman who acquired a thorough mastery of Sanskrit, and brought his profound learning to bear upon its palæography, so as to decipher several of the ancient inscriptions which were unintelligible to the pundits of his time. His successor, in many of his offices, was Horace Hayman Wilson, whose grammar and dictionary of Sanskrit, his translations of the Vishna Purana and Mega Dûta, and his Theatre of the Hindoos, stamped him as the fit occupant of the Boden chair at Oxford, which he held until his death. These and others all laboured in the cause of archæology in its widest sense; but the next name is one which will be ever remembered as that of the great pioneer who opened out the hidden recesses, and threw a blaze of light into the previously dark places of the archæology and numismatics of India—James Prinsep, who for some years was secretary, and enriched the society's journal with his discoveries. To him we owe, mainly, the decipherment of the ancient alphabets in which the inscriptions on the earliest coins, copper plates, and stones, were recorded, a knowledge of which has opened up to us so much of the early history of Asia, and whose most modest suggestions, and even casual hints, have scarcely ever been proved by subsequent investigation to be otherwise than correct. His premature death has been universally considered one of the greatest losses the cause of archæology in India ever sustained. To these may be added the names of Sir John Shore, Wilford, Bentley, Kitto, and Dr. Mill, to complete the roll of the past. Of the living members, I should mention the veteran Brian Houghton Hodgson, who did so much to open out Nepaul to European scholars, and who utilised the very favourable opportunities his position as Resident there for so many years gave him for carrying on literary and scientific pursuits. His contribution of more than 100 papers to the journal, besides a large collection of MSS., lately classified by Dr. Mitra, and many specimens of natural history, laid the society under great obligations. One other name I must add, that of Baboo Rajendralal Mitra, LL.D., C.I.E., who after labouring for the society for many years, in various offices, was on the last vacancy elected its president, a distinction he had well earned from the good service he had rendered, especially in regard to the preparation of the "Bibliotheca Indica," as also for his own independent publications.

The "Asiatic Researches," in 20 vols., 84 vols. of the Journal and index, 19 vols. of Proceedings, 167 of Oriental works, 31 of miscellaneous works relating to India, 14 of catalogues, and 18 of Sanskrit works, record what has been done by its members.

Some twenty years after the Asiatic Society was established in Bengal, Sir James Mackintosh, the then Recorder of Bombay, put forward a proposal to establish a similar one at that place, and, on 26th November, 1804, "The Bombay Literary Society" was founded, which, in 1827, became "The Bombay Branch of the Royal Asiatic Society," by which title it still flourishes. Its rolls also show a number of names well known as scholars in Indian history and archæology—such as Lieutenant-Colonel Boden, who founded the Sanskrit chair at Oxford; Captain John Briggs, F.R.S., whose contributions to almost every department of literature and science connected with the East are so well known; William Erskine, the author of the life of Bâbar and Humâyan; General Vans Kennedy, the author of "Hindoo Mythology," "The Origin and Affinity of Languages," and many papers in the home and Bombay Societies' journals, testifying to his varied and extensive learning. The above, together with Lord Valentia and his travelling companion, Henry Salt, F.R.S., early writers on India and the East, were at the foundation meeting. In more modern times, I may mention the Rev. Dr. John Wilson, F.R.S., the well-known missionary educationalist, famed for his intimate knowledge of India, its history, antiquities, and the manners and customs of its people; the Rev. Dr. Stephenson, who, with Colonel Meadows Taylor, the Brothers West, and Dr. James Bird, assisted the Cave Temple Commission to prepare and decipher the inscriptions collected; Mr. Justice Newton, whose researches into the coins of Sujrastra afford much information on that period of history; and Dr. Bhau Dhaji, who personally, and by his great influence over others, did much to collect and make use of the inscriptions and archæological remains of his Presidency. The society has published three quarto and eighteen octavo volumes of proceedings and journals.

In Madras, the Literary Society owed its foundation in 1816 to Sir John Newbold, the Chief Justice, assisted by Messrs. Benjamin Guy Babington, Francis Whyte Ellis, C. M. Wish, and Major-General Cullen. It did not, however, flourish, owing to the death or departure of some of its founders very shortly after its formation; it suffered especially from the death of Mr. Ellis, who was probably the ablest Dravidian scholar we ever had, and whose sudden death, in 1819, is still deplored. It was, however, resuscitated by Sir C. E. Grey, the next Chief Justice, and in 1827, the first part of its transactions appeared in quarto, published by Longmans; no more were published, and Sir C. Grey's promotion to Calcutta again caused the society to languish until 1833—five years after it had been affiliated to the London Society—when under the patronage of the Governor, Sir Frederick Adam, it took a fresh start, and following the example of the Calcutta Society, commenced publishing its transactions locally, the first number in 1834. Its publications have not appeared very regularly, but in all 27 vols., large and small, have been issued.

The first collector of ancient inscriptions was Colonel Colin Mackenzie, who prepared a fine collection of copies from stones and copper-plates, in triplicate, one of which was sent to the India-house, another to Calcutta, but I have not been able to trace the third. To this collection my venerable friend, Sir Walter Elliot, to whom I am indebted for this sketch of the rise of the Madras Literary Society, has contributed very many, as also Mr. C. P. Brown and Mr. C. M. Wish. These have again been augmented by others, and some attempts at collation and translation have been made by the late Dr. Burnell and Mr. Fleet, the present epigraphist to the Government of India, and other scholars. Sir Walter Elliot collected 595 tablet inscriptions in old Kanarese and Sanskrit from the Kanarese portion of Southern India, and a great many in Telegu from that portion. Two volumes of these are now in the library of the Edinburgh University, but have as yet been made very little use of; Mr. Fleet has, however, examined them with the view of publication.

Amongst the retired Anglo-Indians who kept up and enlarged their connection with the antiquities, numismatics, and archæology of India, it is grievous for me to mention the names of James Fergusson and Edward Thomas with the prefix of "late;" both were alive when I commenced collecting materials fo this paper, and took much interest in it, and the former, only four days before he was struck down, was warmly urging me to the work and offering me his own most valuable assistance. Both have gone to their rest, and doubtless full notes of their works and merits will appear by abler pens than mine; but I could not allow this opportunity to pass without prominently alluding to my two old friends and collaborators in the work of Indian archæology. There are many other names which I might mention if time and space permitted, but I must refrain.

Archæology in its widest sense occupied the attention of many of the members of these four societies, as will appear from a reference to the publications. We hardly find a volume of the "Asiatic Researches" which does not contain, besides papers on ancient buildings, old inscriptions, sculptures, and prehistoric remains, researches into the early history of the country, its original races, the Mauryas, Andhras, Græco-Bactrians, Indo-Bactrians, and Indo-Scythians, the Mitras, Guptas, and others; while numismatics, though not often brought to notice, were not wholly omitted. The later journals show how well the successors of the earlier contributors have kept up the supply, and by their discoveries have aided greatly in bringing to light the vast stores of information so long hidden from the world. In fact, we are dependent on the proceedings of these societies, and the labour of their members, for all the knowledge we had on this great subject—certainly up to 1862, when a new era commenced. Much had been done, spasmodically it may have been. At one period many active labourers appeared in the field, at another the science met with great neglect; but still something was always being done, though as yet Government had given no helping hand.

In 1862, General (then Major) Alexander Cunningham, of the Bengal Engineers, who had devoted all the spare time of many years of his life to the study of the numismatics and antiquities of India, drew up a memorandum, at the request of Lord Canning, the Governor-General, which met with approval, and what is now the Archæological Survey of India was commenced. For the first four years (1862-65) General Cunningham worked alone, and the results are shown in the first two volumes of reports. Lord Lawrence having, however, stopped the work, the General resigned the service and returned to England, where he remained until 1871, when, at the invitation of Lord Mayo, he returned to his former labours, and with two assistants has continued working until last year, when he resigned his appointment, with the intention of returning to England. An opportunity thus occurred for a revision of the establishment, to which I shall allude more fully hereafter. Twenty volumes of reports have been published, and I believe four or five more are nearly ready; and here I must express a deep regret, in which I feel sure my audience will sympathise, that the notes of years, the books, and, I fear, some of the curiosities he has collected—to the extent of 45 cases, which were coming home before General Cunningham—have been lost in the P. and O. Company's steamer *Indus*. I was in hopes some portion might have been rescued, but from the latest accounts I fear the vessel has broken up and that everything is totally lost. This is indeed to some extent a national misfortune, and will prevent our benefiting by much of the labours of a lifetime spent in archæological pursuits.

This survey, however, did not extend beyond Bengal, the North-West Provinces, and the Punjaub, with parts of Central India and Ragpootana; but it has produced good fruit, for, besides the volumes of reports, some special works have appeared, viz., Cunningham's "Ancient Geography of India," the Buddhist period, his "Stupa of Barhût," and his "Corpus Inscriptionum Indicarum;" Dr. Rajendralal Mitras' "Buddya Gaya," and his larger work on "The Antiquities of Orissa;" while, in England, we have had the splendid work on "Tree and Serpent Worship," by the late lamented James Fergusson, in which the Buddhist sculptures of Sanchi and Amravati are illustrated and explained. The cost of all but the first-mentioned was borne by the Government of India.

But as yet the survey had not been extended to the Bombay or Madras Presidencies, and although various Secretaries of State had from time to time written out urging on the local Governments, and also on the Government of India, the necessity for surveying the ancient remains in those Presidencies, hardly anything had been done up to 1873. Lord Iddesleigh, then Sir Stafford Northcote, and Secretary of State, so far back as 1867 had intimated his consent to a yearly sum of Rs.13,000 being allotted for this work in each of these Presidencies, and the Duke of Argyll had specially urged on the Bombay Government the necessity for a survey of the rock-cut temples of Western India to enable Mr. Fergusson to bring out his long projected work on that subject, but nothing had actually been commenced.

In 1873, I became a member of the Bombay Council, and at once took up and reviewed the entire subject from the Government records, with the result that I found the sum total of the work done in Bombay was confined to the purchase of a large number of photographs, taken by various amateurs, of ancient buildings scattered over the Presidency, but without any attempt at systematic classification; and in addition a survey had been made and some casts of the details taken of the Temple of Ambenauth in the Konkan.

I should, however, mention that in 1865 a committee had been formed in Bombay under the auspices of Sir Bartle Frere, the Governor, and a warm friend to the cause, to prepare for publication a series of volumes of the "Archæological Antiquities of Western India;" each volume was to be published under the patronage and at the expense of a native gentleman, several of whom had agreed to give £1,000 each towards the cost. Mr. T. C. Hope, now a member of the Viceroy's Council, was the editor, assisted by Mr. Fergusson as to the architectural details, but only three volumes were issued, viz., (1) "Ahmedabad," and (2) "Dharwar and Mysore," under the patronage of Mr. Premchand Roychand; (3) "Beejhapore," under the patronage of Mr. Kursondass Madhoadass, when the commercial crisis, on the close of the American war, occurred and prevented many of those who would otherwise have carried on this work from fulfilling their intention. The photographs used in these books were those which had been previously purchased by Government, as I have above mentioned.

Mr. (now Dr.) James Burgess, C.I.E., had been for some years one of the most active members of the Bombay branch of the Royal Asiatic Society, and had done far more than anyone else to survey, photograph, or sketch the ancient monuments of the Presidency. He had for years so employed himself during his vacations, and had started a monthly periodical called the "Indian Antiquary," which was devoted to the subject, in which also he had commenced the publication of *fac-similes* of inscriptions, together with their transliteration and translation. He was about to return home for good, having taken his pension from the educational institution over which, he had for some years presided, when, finding he was much disappointed that Government had not employed him in the work which he had so deeply at heart, and thus availed themselves of the great experience and valuable collection of materials he had acquired, I fortunately prevailed on him to delay his departure, and await a reply to a communication which was at once made to the Supreme Government for permission to commence the survey on Bombay; this was granted, and Dr. Burgess was appointed to its head. The annual sum, Rs. 13,000, was small; it has since been increased to Rs. 18,000; but the work produced will, I think, bear comparison with any of a similar nature in any other part of the Empire. Five volumes have been published, viz.:—(1) The district of Belgaum and Kaladgi; (2) the district of Kattiawad and Katch; (3) the district of Bedar and Aurangabad; (4) the Buddhist cave temples of Adjuntah, Karli, &c.; (5) the Ellora cave temples; another volume is in the press, and materials for two more are ready; while the result of the survey of the cave temples enabled Mr. Fergusson, in conjunction with Dr. Burgess, to produce the long contemplated work on these singular monuments of the past, which was published under the patronage of her Majesty's Secretary of State. In addition a few volumes only, I believe, containing impressions of the inscriptions which had been photographed were prepared for the use of scholars, with an introduction by Mr. Fleet.

In Madras, very little was done after Sir Walter Elliot left, until about 1876, when Mr. R. Sewell, of the M.C.S. took up the subject, in which he was much interested, and after having read up all the information he could obtain, proceeded to put his knowledge into practice, and on his appointment to the Krishna district, having obtained a small grant of Rs. 1,000 from Government, he proceeded with the excavations of the Amaravati Tope; and also cleared out several cave temples at Undavalle, Bêzvâda, and elsewhere, besides discovering a new tope at Jaggayapêta. His reports were published by the Madras Government, and his ability as an antiquarian scholar became known both in India and England. He has written various papers for the journals of the Asiatic societies; but his principal works are one published in 2 vols., 4to, by the Madras Government, in the preparation of which he was employed from 1881 to 1883. The first volume contains a topographical list of the antiquities in Southern India, distributed according to the districts in which they are situated. This large amount of valuable information was prepared in anticipation of the survey which it was hoped would soon be established. The second volume contains a list of copper-plate prints, inscriptions chronologically and dynastically arranged, and a sketch of the dynasties of Southern India; this latter is merely tentative, and can only be perfected from the examination and collation of the many hundreds of inscriptions from which alone correct historical data can be obtained. His other work is on the Amravati Tope.

After several proposals had been made, the objections to which were too apparent, the archæological survey of Madras was placed in Dr. Burgess's hands, and with two assistants he has already prepared a large mass of valuable information, many beautiful drawings, and accurate surveys, enough for five volumes, and I trust will soon be allowed to begin publishing them. He has found Mr. Sewell's preliminary lists and reports of very great value and service to him; and I have no hesitation in saying that archæology is very deeply indebted to that gentleman for what he has done in Southern India; if it had not been for him we should have remained without any fresh information or discoveries, in fact, no progress would have been made in archæology in Madras, from the time Sir Walter Elliot left the Presidency, until Dr. Burgess's survey was introduced, had not Mr. Sewell taken the matter in hand.

In addition to the survey under General Cunningham, Sir John Strachey, when Lieut.-Governor of the North-West Provinces, took up the special case of the royal buildings in the forts of Agra and Delhi and their neighbourhoods. A restoration of these buildings—much of the damage to which had occurred at the time of the Mutiny, and shortly after, from the hands of our soldiers and fellow-countrymen—rendered such a course desirable on other than purely archæological grounds, and under the able care of Mr. Heath, of the Public Works Department, this has been carried out at a very large cost; and the remains of the palaces, &c., in the forts of Agra and Delhi, at Futtepore-Sikri, with the tombs of Akbar, Itm-ud-dowla, and that wonderful monument, the Taj, have not only been rescued from decay and destruction, but have been restored with such scrupulous care, and are now in such a state of preservation, that, with the annual inspection provided for, they will, I trust, last as long as, at all events, the British Government remains paramount in India.

In 1878, several instances had occurred in Bombay in which ancient buildings had been repaired by the Public Works Department in anything but a creditable manner, in fact, they had been sometimes irreparably injured. I will give one instance—a friend of mine, then a collector and magistrate in Guzerat, during one of his tours came across a fine old building sadly in want of repair. He was an archæologist, and at once sent in an application to Government, who sanctioned the work, and ordered the public works officer of the district, a Royal Engineer, to carry it out. The next season, my friend, hearing the repairs had been completed, hastened to see his restored relic, when to his utter disgust, he found that on completion of the repairs, the building had been covered with slate-coloured wash in the same manner as the barracks and outbuildings are by that department. This led Sir Richard Temple's Government to appoint the late Major Mant, R.E., as curator, to superintend all repairs and restorations. A similar want having been found by the Government of India in 1881, the Secretary of State sanctioned such an appointment for three years. Major Cole, R.E., who was made curator, issued three annual reports, and also had some drawings reproduced at Paris by Morel and Co.; but it was found that it was better to leave the matter in the hands of the archæological surveyors to check the Public Works Department, and that the expense would not justify a renewal of the appointment, and it in consequence ceased.

General Cunningham having expressed his desire to retire from India, his appointment has been broken up, and, in lieu of our Director General with two assistants, Bengal, the North-West Provinces, and the Punjaub, together with Rajpootana, Central India, and Chota Nagpore, has been formed into three districts, and a surveyor, with two or more assistants and staff, as in Bombay, appointed to each. Dr. Burgess will be the general referee and adviser of the Government of India, but will remain in personal charge of his present work in Bombay and Madras. Under this arrangement, every part of the Indian Empire will have its archæological surveyor, who, with his assistants, will be able, before many years are over, to give us a very full and careful account of all the ancient monuments, and will enable the Government to publish much interesting and valuable information on the subject.

Another branch of archæology, to which I have above alluded, is the collection and translation of the ancient inscriptions on rocks and stones and copper plates, which abound in many parts of India. The earliest collection was, as I have already stated, made by Colonel Colin Mackenzie in Southern India; this was followed by additions made by Sir Walter Elliot, and others, by the Cave Temple Commission, in connection with the Bombay Asiatic Society, as well as by private individuals who appreciated such records, amongst whom I may mention the Rev. Doctors Stephenson and John Wilson, Dr. James Bird, the Brothers West, and Dr. Bhau Dhaji; while General Cunningham had also succeeded in procuring a large number, especially those connected with the Gupta dynasty; but nothing had been done towards their systematic publication, transliteration, and translation, excepting those inscriptions which had been published in the "Indian Antiquary," edited by Dr. Burgess, the translation and transliteration of which were prepared chiefly by Mr. Fleet, Professor Bühler, and Pundit Bhugwunlal Indraje, to the last of whom, especially, this branch of archæology is much indebted. In 1882, however, I am glad to say the Secretary of State approved of a scheme put forward by the Government of India, by which an epigraphist was appointed for this special duty. Mr. J. F. Fleet, C.I.E., of the Bombay Civil Service, was selected for the work; he had been, as I have already mentioned, for some years engaged with the Elliot and other collections, and had published a good many articles or papers in the columns of the "Indian Antiquary," and had also, as a contribution to the *Bombay Gazetteer*, drawn up a valuable account of the Hindoo history of India from the earliest times, to A.D 1318, founded chiefly on the information he had acquired from the inscriptions he had translated. At General Cunningham's suggestion, Mr. Fleet commenced his new duties with the Gupta portion, and the first volume is nearly ready to be issued. A good deal of delay has been caused from the imperfect state of the copies which had been taken of many of the inscriptions, which necessitated fresh ones being procured. The plan adopted is to take from the stone or plate a *fac-simile*, either by a rubbing on paper or by an *estampage*, which is a mould made by beating wet paper into the letters by means of a brush, and allowing it to dry before removal. Accurate copies of these, on a reduced scale if necessary, are taken by photography, and produced on paper by one of those novel processes discovered of late years. This plan has great advantage over the former system of hand-made copies taken by the eye, and similarly reduced, as adopted by General Cunningham in his "Corpus Inscriptionum Indicarum," published by the Government of India in 1877, and which were always liable to error, however carefully done. Under the new plan, the inscriptions appear with all their imperfections on the paper just as on the original stone or plate, and so all those scholars who are interested in the work can criticise Mr. Fleet's translations and suggest improvements.

The practical result of this appointment will be a vast amount of new historical matter—the fixing of dates and the names of rulers in ancient days—thus enabling us to fill in many of the *lacunæ* existing in early Indian history. This important branch of archæology has thus been placed in a promising position, and its results may be looked for with every hope of success. The number of inscriptions is, however, very great, and on the expiration of the three years for which the epigraphists appointment are sanctioned, it may be necessary to reconsider it with a view to obtaining more assistance than is at present available.

A further contribution to the study of the cave temples has been made by Mr. John Griffiths, of the Bombay School of Art, who has for some ten years past been engaged with his pupils, every cold season, in copying full size the fresco paintings in the Ajunta caves. It will be remembered that those very accurate copies taken by the late Major Gill were burnt in the Crystal Palace, and as it was found that age was rapidly destroying what was left of the frescoes, the Bombay Government appointed Mr. Griffiths to the work, and a very large amount has been accomplished. Curiously enough, some of these also were injured at the fire last year at South Kensington.

The above, I believe, gives a pretty correct account of the steps which have been taken to secure the carrying out of a complete archæological survey in India, and it has already been shown how fully the results justify the cost, not only from an antiquarian and archæological point of view, but more especially as a means whereby great additional information has been derived for settling the early history of the country.

In spite, however, of what appears to be the clear duty of a civilised Government in regard to the ancient monuments it has inherited, as well as its manifest use in affording the only safe evidence of the history of the past, it is surprising to find how little support or encouragment archæology meets with from the great majority of the officers of Government; many very able men speak openly of the survey as a waste of money, and the surveyors and others engaged get but too often the cold shoulder of officialism, and find the bands of red tape tightened to their discomfort and hindrance. Unless it so happens that a member of the Government is personally interested, a director or surveyor finds it very uphill work. A secretary or some junior officer "pigeon-holes" a report, not knowing, perhaps, how to deal with it, or contents himself with announcing his opinion that "we govern the living and not the dead," and so would relegate all archæological matters to that oblivion in which they so long remained. Much of this I have personally felt, and, even in the higher positions I subsequently held, have seen how difficult it was at times to overcome the *vis inertiæ* of those who, thinking the whole subject purely dilettanti and unpractical, but not daring openly to oppose a member of the Government, used all the powers of the secretariate to delay and thwart the work. The number of gentlemen who now, like Mr. Sewell, take interest in it may be counted on the fingers; but it is in hopes that a change may come on, when the feelings of those interested in the work here at home become known in India, that formed one reason why I have consented to give this lecture.

The subject of restoration is one of great importance. Opinions differ largely as to what should and what should not be done. I must say I am not one of those who would give up a building to time to complete its destruction, when by some careful repair, a new stone or two, or a beam or a buttress, it might be kept standing for years, especially in India, where the climate and speedy growth of vegetation injure buildings rapidly. Of course I do not mean that we should, on the strength of a few stones found *in situ*, a mere fractional portion of the former structure, attempt to reproduce a building supposed to represent the original, as was in one case suggested! I would not hesitate to replace stones which have fallen, or put in fresh ones to hold the others in their places, or to take down and rebuild portions of buildings likely to fall. Perhaps the best example of this sort of restoration was the rebuilding with the original marble blocks the pearl mosque at Delhi, the domes of which had fallen during the siege; the taking down and rebuilding one of the minars of the Taj which was in a dangerous state; and a similar work at Ahmedabad; while at Futtipor Sikri a few new stones put in here and there, and the replacing of old ones, has stopped further decay.

Mr. Heath's restorations of the buildings at Agra and Delhi have been carried out in a most conscientious manner, and the repair of the mosaic, which suffered most from our own soldiers and fellow-countrymen, has not only been successful, but has revived this branch of art at Agra, specimens of which will doubtless appear at the coming Exhibition. I must here allude to one matter to which public attention should be drawn, in order that a restoration of another sort may be the result. When the fort of Delhi was taken in 1857, great havoc was made in the palace buildings, and the screen behind the emperor's seat in the Dewani Am, or hall of public audience, was sadly mutilated and despoiled of some of the larger mosaic tablets. A gallant officer in high command appropriated several, and having had them converted, I believe, into tables, sold them to the South Kensington Museum. One of them was the famous picture of Orpheus charming the animals, which is said to contain the portrait of the architect employed by Shah Jehan, Austin-de-Bordeaux. I trust that as the screen is now being restored, those tablets may be returned, and replaced in their original position.

I must allude to another sort of restoration, which was used by Major Keith, under Major Cole's instructions, in the Sanchi Tope. The large gateways which had long before fallen to the ground, and of which portions had been removed by the natives residing near both for building materials and making lime, were collected and carefully re-erected on their original sites, those pieces wanting, and without which the work would not stand, being supplied by pieces of new stone left plain.

One other method of restoration has been made use of—it is not singular to India—it is the removal of the masses of white and coloured wash, which from frequent repetition have at length become a thick coat of plaster, with the result of hiding all the beautiful carved work on the marble or stone; this certainly had one benefit, is preserved what was beneath, and now when our workmen get at it they restore to view the beautiful chasings on the stone in about as good a state as when they left the chisel of the original sculptor. A particularly good instance of this sort of restoration was carried out by Major Keith on the Palace of Mansing, in the Fort of Gwalior, which we have just made over to His Highness the Maharajah Scindia. I trust that Lord Dufferin, who takes a great interest in archæology, will give the Maharajah a hint not again to cover up what we have restored, and also that he will preserve the other curious buildings we have placed in repair in this fort.

It would be impossible for me, in a paper of this nature, to give any detailed list of what has been done—the Reports will show a great deal of the work—but I may add that of my own knowledge, in almost all parts of India, in Bengal, the North-Western Provinces, the Punjaub, Madras, Bombay, and Sind, much has been done and many fine buildings rescued from ruin.

I will now call your attention to the drawings which appear on the wall behind me. These will give you some idea of the work done, and also afford an insight into the very wonderful architecture and ornamentation which is to be found in the old buildings in India and which it is our desire to preserve.

I have shown how much is done towards this, but I would utter a word of caution. The number of these old buildings is very great, in some districts they appear in profusion, capitals like Delhi and Agra are surrounded by them, while in the neighbourhood of any famous shrine there are to be found hundreds of tombs of persons who wished to lie near the sainted remains and so acquire a better chance hereafter by rising in his company. But the great majority of these tombs, mosques, and temples, are more or less in a state of disrepair, which forbids any attempt to save them from utter decay, especially in those parts—and they are many—in which the ground is impregnated with saltpetre; while those which require repair and might receive it are so numerous that the expenditure required is far greater than the Government can afford or could be justified in expending; this is too often forgotten, and complaints are made by travellers who, having come across some fine tomb evidently needing repair, at once accuse Government of neglecting its duty, not thinking that nothing less than an unlimited supply of money could possibly do all that we would wish to see done. Unfortunately, the natives of India take no interest in such matters, and, as a rule, no native will repair the tombs of his forefathers.

As a warning to those who abuse the Indian Government for not taking care of their ancient monuments, I may relate what the late Mr. Fergusson told me the last time I saw him. He said he had been shown the first number of a publication on Indian monuments by a French *savant*, who had travelled in that country, which had just been published in Paris, in which he found the drawing of a temple much dilapidated, and in the letter-press an attack on the British Government—first, for not having prevented its desecration, and next, for having allowed much of its materials to be used for road making, forming a heavy indictment. Mr. Fergusson then showed me a sketch he had made of the same building more than forty years before, showing it had in no way changed its appearance or condition, while its desecration had occurred 300 years ago by the Mahommedans, and the temple itself was not, or ever had been, in British territory.

Full lists of all architectural remains are now being finally revised by the archæological surveyors in each district. These will form registers, and repairs must go on as money can be afforded by the local or Imperial Governments, the most successful works being first taken in hand.

In some places funds have been left for the sustentation of mosques and temples, and we often find that even when they are appropriated to the purpose for which they were designed—and this I am sorry to say is not always the case—the manner in which the work is done is neither creditable to the taste of the directors or advantageous to the building. The subject is one which requires careful handling, but I hope the Archæological Department may be able make its influence felt in the expenditure of such funds.

I have now, in conclusion, only to thank you for your attention to a lecture which I fear has been little else but a dry statement of facts, with little to enliven it or make it otherwise than prosy; but my object has been to make public what has been done, what is being done, and what remains to be done in this interesting branch of study. As to the last, very much does remain to be done, because the field is immense, and the funds cannot reasonably be large which the Government can devote to the object. It would, indeed, be a good thing if we could find among the rich natives of India men like "Nil Desperandum," Sir E. Beckett, Mr. Guinness, Mr. Roe, and others, who would come forward with funds for the restoration of the ancient buildings of their country, or for the publication of the results of the survey. I am in hopes that the spread of Western civilisation will bring about such a change, and that the Government may, in future years, find many earnest and willing supporters and contributors to this great national work.

DISCUSSION.

Mr. R. SEWELL said he was emboldened to make a few remarks by the very kind way in which Mr. Gibbs had spoken of him. The work described was one of great interest to him, as he had resided a long time in the country, and had done what he could to help on the study of archæology. The Madras Literary Society, which began by doing a very excellent work, was now practically dead, he should not like to say for how many years. There was an attempt some time ago to resuscitate it, but at the present time it was nothing more nor less than a large lending library—very little encouragement to the study of archæology. About four years ago he attempted to induce the society to reduce the subscription to about £1 a year instead of £4 or £5, so that those resident in Madras who might wish to use the library, in the same way as persons resident in London might use such a library as that of the Royal Asiatic Society might be able to do so, studying the books there, but not taking them away. His suggestion, however, was negatived with scorn, and practically it was simply a lending library from which people borrowed the leading novels, and he was sorry that the Royal Asiatic Society of England should still call it an affiliated society. Some day he hoped it would be resuscitated. Mr. Gibbs had alluded to the great national loss suffered in the destruction of General Cunningham's collection of MSS., but that was by no means the only case of the kind. The whole of Sir Walter Elliot's fine collection, consisting of thousands of copies of inscriptions, and the accumulated work of a lifetime, were lost in a ship in which he sent them over to England, a ship laden with sugar. Two or three of the papers which were saved were lent to him when writing his report on the Amaravati tope some years ago, and they were then quite blackened, and smelt strongly of sugar. Another great loss was that of the painting of the Ajuntah tope, in the Indian section of the South Kensington Museum. He could not quite endorse Mr. Gibbs's views with regard to the very few monuments which had really been injured during the British raj, at any rate in Southern India. There were several monuments on the banks of the River Chrishna which had been absolutely destroyed during the British regime. He knew certainly of two old Buddhist topes—and probably there were others—one at Valerada, ten miles from the river, which was of great value, inasmuch as it represented the great dome-shaped old brick structure which the Buddhists were so fond of erecting in that locality; and of that there remained very little indeed. There was an area in the middle of the village with fragments of broken brick, but absolutely nothing of the original structure. Worse than that was the destruction of the tope at Battiprole, on the south side of the Kistna, which must have been still remaining within the memory of man, for he had had descriptions of it by those who had seen it. He had been informed that within thirty years the dome was practically complete, though not altogether in first-rate order; still, what there was was in a very good state of preservation. There were also fragments of the rail round it, showing how it resembled the tope at Sanchi. That rail was constructed of marble, and though it was very much demolished, there remained certainly within the memory of the inhabitants of the village one if not more of the pillars which the Buddhists always erected in connection with such buildings. He could not exactly say whether the sculptures were very elaborate, but the work was certainly very old; and he could speak himself to the fact of these being of marble, for he had seen them. It might be supposed that he had seen them buried underground, or scattered about the locality, or in the village, but he was sorry to say this was not the case. The Royal Engineers had a road to make close by the side of that old tope, and, not the least understanding the value of the monument, they found a splendid supply of large bricks ready to hand in the dome. All the bricks, with the exception of a very few, were utilised in this way, and a very good road they made. Hard by there ran a canal over which the road had been carried by means of an excellent bridge. The canal was only used for irrigation, and the bridge, therefore, had been utilised to make an excellent, and no doubt economical, dam or weir. In the very dry season he visited this place, and found the bed of the canal completely dry, and there to his dismay he saw a large number, forty or fifty, of the original ancient Buddhist marble structures, which had been laid on the floor of the canal, which made an excellent groundwork for the water to flow over at all seasons, except when it was perfectly dry. That was a practical example of the ignorant destruction of one of the most valuable monuments of antiquity. The monolithic remains at Mahábalipur, which were known as the Seven Pagodas, south of Madras, were well known, but it was not so well known that the whole ground was quite recently in the possession of a zemindar. The village in which these monuments lay was given by the Mohammedan Government to the ancestor of the present holder, and when he joined the district in which these monuments lay, close to Madras, about three years ago, he found that the locality, which consisted of a range of hills composed of most excellent granite, most useful for building bridges, &c., had been leased by the zemindar, some years previously, to a family of contractors, who employed gunpowder, dynamite, and, as much as they could, pick-axes and crowbars, to demolish the rock. When he inspected the place, he found there was no great injury done to the monuments themselves; they were very much scattered, and whether any had absolutely been destroyed it was impossible to say, for if they had, they had disappeared; but the work was still going on, and the demolition was gradually extending, the rock being more and more valuable the deeper they cut into it, and every possible attempt, of course, was made by the contractors to make the best use of their time. He made a strong report to the Madras Government, imploring them to take some measures to prevent this traffic, which, if it had not done much damage hitherto, was likely, in the course of years, to produce serious results to the old monuments. Inquiries were made, but it was found that the case presented serious difficulties, because the question arose whether the Mohammedan Government, in making over the village to the zemindar, gave him only the arable land and the village itself, or whether they intended also to make over the entire waste. Now, all the hills out of which these monolithic monuments were carved belonged absolutely to the waste, and it was a very intricate problem, which had never yet been settled, whether the whole, or only a part, had been originally granted. So the matter remained; but two mails ago he received the extremely gratifying information that the zemindar, whose feelings, no doubt, had to some extent been worked upon, had made over, as a free gift to the nation, the whole of the long line of hills which contained these grand old monuments. The result was that the British Government would now spread its ægis over the remains, and he trusted no further injury could possibly occur.

Mr. W. G. **Pedder** said he knew very little of this subject, but he was aware from his official experience at the India-office, that the work which Dr. James Burgess was doing in Western and Southern India was of the greatest possible value, and he hoped the new position which he had taken, which gave him a kind of supervision over the work throughout India, would result in very great benefit. Mr. Sewell had referred to the Adjuntah paintings having been destroyed in the fire at the Kensington Museum, but he believed the paintings, although they had run a great risk, were not destroyed, but only slightly damaged. Those which were destroyed were Colonel Gill's original paintings, which were burnt at the Crystal Palace. Every one acquainted with India knew how great was the difficulty of preserving these ancient monuments. In the first place, the expenditure would be enormous to undertake anything like a general restoration, and in the next place there were questions like that just referred to, in which private rights might be interfered with. At the same time no doubt a great deal might be done in some places to restore valuable antiquarian objects, and still more might be done to preserve those which had not fallen altogether into decay. He believed the Government of India, and all the local governments, were now fully alive to the importance of maintaining these ancient monuments and interesting records, and he hoped for the future they would hear no more of such acts of vandalism as those which had been mentioned, and which had occasionally come under his notice, where ancient works had been used for road metal. He knew the interest Mr. Fleet took in the work, and there was never a more useful appointment made than that by which he was entrusted with the investigation and publication of the epigraphy of India.

Dr. **Pringle** said, having spent many years in Orissa, and seen a greal deal of Bobunshwar, the place known as "the city of a thousand temples," he had listened with great interest to this paper, and only wished he had had an opportunity of seeing the book on the antiquities of Orissa by the learned Dr. Mitra. He did not know whether it contained any pictures of Kanarack or the black pagoda near Juggernaut. But he had looked up some of his old photographs taken when he was quite a beginner, and brought them with him. That wonderful temple which was never consecrated for reasons which the natives gave, and which it is unnecessary to allude to here (for they always had a reason for everything if you would only listen patiently to them), had completely collapsed, but the entrance remained as strong as ever; that was owing to half a dozen strong iron bars acting as lintels, which, speaking from memory, were about 12 ft. long by about 9 in. square. The iron for these bars was obtained in the hills about 150 miles distant, and where they were doubtless manufactured. There were some beautifully carved stones and enormous figures of lions and horsemen, which Dr. Hunter seemed to think had been brought by land carriage. He asked the natives how they were brought, for there was not a stone nearer than the neighbouring hills, and they told him they were floated down on large rafts made of entire new sâl trees, and they were rolled up in these trees, and when he asked them how they got them up that heighth, they said they built a mound and dug it out. [While on this subject a photograph was shown of a bridge in which there was no attempt at an arch, the Attaranullla bridge, or bridge which divided the river into eighteen streams.] This bridge near Juggernaut was built by resting one stone on another, each one projecting slightly beyond the one beneath until they nearly met at the top. One great difficulty in preserving old buildings in India was the growth of vegetation, principally the Indian fig; the seeds rested on the little ridges, took root, and tore the building to pieces in a remarkably short space of time. At Juggernaut he asked the priests why they covered the temple with *chunâm*; they said it was done about 200 years ago, because they wanted to preserve the temple. It was perfectly smooth, so that if any seed fell on it it rolled off, but he was told there were some roots at last getting into that *chunâm*, and they could not replace it, for they did not know how to make it as it was formerly done. With regard to not repairing "the tombs of the prophets," he was afraid it was due to the poverty of the people, or the diversion of the funds into other channels. Around Agra many places were given up to tombs, it being the custom when any great or good man was buried for the whole neighbourhood to be used as a place of sepulchre. On one occasion, when riding through the Boolandshur district, he was told by a native that a wonderful discovery had been made at Indrapore, and a long story was told him about the bones of giants having been found. He rode over and found Mr. Carlyle very busy superintending the digging out of a mound. On asking him what made him dig there, he told him he had found in the river a large copper plate, on which was a statement that the ground in the neighbourhood was to be given to the temple "while the sun and moon endure," which was the usual expression. Mr. Carlyle, therefore, commenced digging; but he apparently at first missed the real temple, though he found portions of it after, and had come on an old tomb, and he dug out, amongst a number of female skeletons, some which the natives had mistaken for giants, but which were really the skeletons of the huge Nubians who were often brought over. They were very tall, the height in several instances being over six feet. With reference to coins, he might mention that he got from a railway cutting in Scinde a beautiful little piece of sculpture of Chrishna entering Matura, holding in his hand his cup, and an umbrella being held over his head. The coin representing that was now in the British Museum. The stone was found in Scinde in cutting a railway, and the coin was found at Kewoj on the Ganges. While at Matura a quantity of copper coins were given to him to select from, and he picked out one of Constantine the Great. In Saharaupur he found twelve coins belonging to the time of Menandra, no two of which were alike. He thought it would be difficult to find twelve sixpences all different, and this showed how extensive the coinage must have been in those ancient times at least 200 years B.C.

Mr. HYDE CLARKE said Mr. Gibbs had referred to Sir William Jones as being the father of the Bengal Asiatic Society; but it had not probably occurred to those who had heard him that it was to the Society of Arts and in that room that Sir William Jones owed the idea of that society. In one of the pictures on the wall would be seen the portrait of William Shipley, the founder of the Society of Arts, who was the uncle of Lady Jones, and was in constant correspondence with Sir William Jones when he was in England, and the plan of the Royal Asiatic Society—which was of a thoroughly practical nature, and has lasted to this day—was formed in conjunction with William Shipley and his brother, the Bishop of St. Asaph; and one of the first honours which Sir William Jones received was that of being elected corresponding member of another society, the Kentish Society of Arts. Their correspondence was, to a great extent, on a subject which deeply interested Sir William Jones, viz., how far the products of India could be turned to account; for it was with that intent that the Bengal Asiatic Society was founded. He was very glad to hear from Mr. Gibbs a vindication of the Government of India and of England in this matter of Indian archæology. Being interested in these matters himself, he had often compared the labours of Englishmen with those of other nations. At the present moment, the Government which was doing most on such subjects was that of the United States, their anthropological department being carried on most munificently. They must, however, look to the way in which those labours were conducted. Their publications were as finely executed as the resources of printing and engraving would allow, but, nevertheless, they did not surpass those of the Government of India, and the labours of the eminent men connected with that department were applied solely to the aborigines of the United States, men who had practically little to do with the governmental interests of the present day. The Archæological Survey of India required no vindication, because it was from the historical results which were obtained from that survey that practical instruction for use in the present day was derived. They heard a great deal about India for the Indians, but what was the evidence that the archæology of India gave? That nearly every part of India, and sometimes the whole of it, had been in the hands of various changing and foreign dynasties. Another Government which had competed with us in these matters, sometimes very munificently, was that of Russia; but he was bound to say the labours of their officers by no means surpassed those of our own countrymen. There was a practice in this country of depreciating what was done by English scholars, but when one thought of the names which Mr. Gibbs had enumerated, and the real value of their labours, it would be found that on their investigations the efforts of foreign scholars had been founded. If they looked to the publications of some French or German society, it would be seen that their investigations were carried out with our own materials, and their articles were founded on the inscriptions to which Sir Walter Elliot applied himself, and it was not the fact that they showed deeper scholarship. People were in the habit of talking of the publications of the Asiatic Society alone, without reference to other societies in London which took up the same subject, and to the Bengal Asiatic Society, and the Bombay branch had likewise done a great deal of very valuable work. With what the Government had done, and the efforts of individual scholars, there was an amount of work produced which far surpassed, not merely that of the scholars of any Oriental school in Europe, but of Europe altogether, and what had been done by other countries had been done with materials collected by Englishmen. When Dr. Pringle spoke of its being owing to the poverty of the natives in India these monuments being in disrepair, he would ask him, who had such a wide experience, whether he knew of any other country where the monuments were kept in good repair. In those numerous cities which he must have passed through from India on his way to Europe, if the monuments had been repaired, they had been repaired as they had in India and other countries from time to time, where there was some wise enlightened public-spirited Sovereign who applied the funds of the State for the purpose. Even in Europe it was the common practice for men not to repair the tombs of their fathers—and we could not say too much of what was done even in this country—but for a man to put up his own monument, perhaps leaving a finer work to perish. He need scarcely say, although it was an idle tribute, that one could not listen to this record of Mr. Gibbs of the labours of the past, without a feeling of gratification that he should have brought it before the Society, but with a feeling of great pain when one thought of some of the names enumerated which had been so lately lost.

Mr. Martin Wood said it was impossible for him to listen to this paper and discussion without recalling a scene in a very different room, where the position of the chairman and Mr. Gibbs were reversed, where Mr. Gibbs used to be president and Dr. Birdwood used to be reader, and that fact was intimately connected with that section of the paper which referred to the establishment of the Bombay Literary Society, as it was called, by its principal founder Sir James Mackintosh. It should not be forgotten that the records of the first twenty years of that Society, in fact its whole history before it became a branch of the Royal Asiatic Society, had been preserved by the efforts of a native friend of Mr. Gibbs, at whose expense and trouble those early volumes were edited and re-published—he referred to the Rao Sahib Vishvanath N. Mundlik. He thought Mr. Gibbs had scarcely done justice to the disposition of the natives of India to take a pride in and contribute towards the restoration and maintenance of these ancient objects. Very handsome donations were given when some who had now passed away had the power to do so in those prosperous years from 1861 to 1865 and 1866. He had been much struck by the self-abnegation of Mr. Gibbs in making scarcely any but a passing reference to that department of archæology in which he was himself so great a proficient, viz., numismatics. Without that the science of comparative archæology would be incomplete, because it was owing to the many discoveries in that direction that the dates and sequence of events had been made out, and Mr. Gibbs had himself done a great deal in that particular branch of science. With regard to the financial aspect of the matter, it should be borne in mind when reference was made to the liberality of the Government, and when it was stated that the Secretary of State had done so and so in publishing various works, that all those expenses were at the cost of India, and not defrayed by the British Treasury.

Mr. Sewell said he did not know anything which would advance the preservation of ancient monuments in India more than the discovery of some means of checking the growth of tree roots on the temples. All sorts of things had been tried in Southern India, but they had discovered absolutely nothing effectual. They had burnt the roots with red-hot crowbars, and some people had suggested putting sugar upon them, in order to attract ants and other insects, but he did not think that was very practicable. If any remedy were discovered and made known, it would be invaluable.

Mr. Liggins said he once heard Sir Joseph Hooker say that one of the best applications would be corrosive sublimate.

Dr. Pringle remarked that the natives themselves said, if they can by any possibility bore a hole into the plant when young, and pour boiling water into it, it would die at once. The ants would not do, for they would carry away the earth from between the stones and loosen them.

The Chairman, in moving a cordial vote of thanks to Mr. Gibbs for his valuable and very interesting paper, said at that late hour the only remark he would make was that there were other antiquities in India, and deserving of at least equal consideration with the material ones of ruined tombs and temples; and that the growing interest of Englishmen in the latter, he hoped, afforded a just assurance of their growing appreciation in the future of the unimpaired vitality and ready adaptability to changing circumstances of the religious and social institutions of a great historical people, whose civilisation had successfully sustained all the shocks and vicissitudes of over 3,000 years.

The vote of thanks having been passed unanimously,

Mr. Gibbs, in acknowledging the compliment, said he would not detain the meeting with any further observations, as the remarks which had been made all seemed to point in the same direction as his own, and did not call for any reply.

Capt. R. C. **Temple** writes:—I have been prevented from attending the reading of this valuable paper, but I should like to add a few remarks to Mr. Gibbs's account of the recent study of Indian epigraphy. As one of the present editors of the "Indian Antiquary," I need hardly say that I fully appreciate the importance of epigraphy in this connection, and can, to some extent, explain the difficulties under which its students labour. In a land like India, where the genius of the people does not incline them to accurate historical statement, and where the writers have no notion of dates, epigraphical records are of primary value when dated; for since many of them are grants, the names of the grantors (generally rulers of some kind) and their dates become matters of everyday practical importance to the grantees who possess and preserve them. Hence the frequency with which they contain both these all important items. When genuine, such grants afford information at first hand, the value of which far transcends that of the reports of the scribes, even when contemporary with the events they relate. They conclusively prove—and they alone—the facts which they state, viz., the names and lineage of the kings who made them, and the time when they ruled. But there is a difficulty here, and no small one either. These local rulers followed more than one era, and the fixing of the initial year of these eras can only be arrived at by putting two and two together; by comparing the dates of the inscriptions of many dynasties with each other. To show how difficult a matter proving the date at which any given Indian era really commenced is, I may mention that Mr. Fleet is only now about to publish a series of inscriptions, by which he hopes to finally settle the long disputed question as to the epoch of an era of such fundamental importance as that of the Guptas. It is clear, then, that the historical truth of the facts of early Indian history can only be reached by the correct decipherment and rendering of as many of the epigraphical records as are available. This means the close consideration, involving the publication of an approximately complete "Corpus Inscriptionum Indicarum." Of course a single publication like the "Indian Antiquary" can only do a portion of the work that is required, and some of the difficulties in the way of achieving what has been already done by it I will now indicate. A scientific publication, however high its aim, can only live in the same way as do its purely commercial contemporaries. The measure of public support accorded to it dictates the length of its life; it has, in short, to cater to its public, if it would continue to live and do useful work. Now during the fifteen years that the "Indian Antiquary" has managed to flourish I think it will be admitted that the most valuable service it has done is the preservation and publication of a large number of inscriptions that prove historical facts and settle dates. Mr. Fleet's Sanskrit and Old Cananese series alone numbers over 160, involving the publication of some hundred of *fac similes.* Hardly a number of the journal is published without one or more epigraphical subjects appearing, and every *fac simile* plate costs a sum to be estimated in pounds sterling; so that the epigraphical papers are, and have always been, our greatest source of expense, and it may now surprise my readers to be told that they are, and have always been, also our chief danger. The fact is they are dry reading, and to any one not an expert in early Indian history, it is not always apparent why a particular inscription is inserted and published at so much expense. "I don't care twopence what King Samanta Deva III., of heaven knows where, granted or did not grant in the year 889 A.D., and I am not going to read about it," is a remark of a sort I have had more than once made to me; though of course it is only by carefully considering such apparent trifles that real history is built up. I could name two gentlemen, both well known for philological and ethnographical studies in India, who ceased to subscribe to us because of the frequent inscriptions. Over and over again have both Mr. Fleet and myself been advised to drop, or at any rate to largely reduce, our epigraphical papers, and we have, as a result, been to some extent obliged to fall in with the prevailing wishes of our subscribers, and at least to "gild the pill," as it were. I do not mean by this remark to disparage much else that scholars are good enough to contribute to our pages. Such papers as Mr. McCrindle's, on "The Indian Geography of Ptolemy," and Professor Ball's "Researches into the Ancient Greek Notices of Indian Animals and Plants," for instance, would always be of value. I merely wish to show how difficult is is to bring inscriptions before the public at all. The natural difficulties in the way of the publication of the results of epigraphical research are—the expense of collection, the expense of translation, when a competent scholar has been found, the expense of reproduction and publication when translated, and the difficulty of finding a public willing to contribute towards the publication. At the same time their primary importance to the study of archæology is beyond question. Before closing my remarks, I wish to pay a tribute to the services of my friend and co-editor, Mr. Fleet, to the science of Indian epigraphy. It is no exaggeration to say that he has done more than any scholar living towards the accurate presentation of these records of the far-distant past, and the settlement of disputed points; I may say, indeed, towards the discovery of the very existence of many data, and so towards the filling up of many wide gaps in the history of our great dependency.

The paper was illustrated by a series of drawings, showing the architecture and ornamentation of the old buildings of India. One of these will be reproduced as a supplement to the *Journal*, and will be issued with the number for April 23.

EIGHTEENTH ORDINARY MEETING.

Wednesday, April 7, 1886; Lord ALFRED S. CHURCHILL, Vice-President of the Society, in the chair.

The following candidates were proposed for election as members of the Society:—

Donkin, Edwin Bryan, Southwark-park-road, Bermondsey, S.E.
Douglas, Charles Stewart, Manor-lodge, Sutton, Surrey.
Douglas, William Carstairs, Manor-lodge, Sutton, Surrey.
Fletcher, Alfred E., 57, Gordon-square, W.C.
Leake, Charles Frederick, Hale-house, Staines, Middlesex.
Lockwood, Philip Causton, 1, Gloucester-place, Brighton.
Manchester, Duke of, K.P., Kimbolton, St. Neots, Hunts.
Porter, Edmund Robinson, 16, Daleham-gardens, South Hampstead, N.W.
Quick, Frederick James, New University Club, S.W.
Ripley, Henry, Owston, Doncaster.
Watt, George, M.B., Revenue and Agriculture Department, Calcutta.
Williams, Oliver John, 38, York-road, Westminster, S.W., and Harwich, Essex.
Wragge, George E., 47, Belvedere-rd., Lambeth, S.E.

The following candidates were balloted for and duly elected members of the Society:—

Audsley, G. A., Devon Nook, Duke's-avenue, Chiswick.
Bromhead, Horatio K., 245, St. Vincent-st., Glasgow.
Cracknell, John Edmund, Glan-y-mor, Havergal-villas, Green-lanes, Wood-green, N.
Crocker, Frederick Joel, 147, Cannon-street, E.C.
Darke, Edward Thomas, 16, Rochester-terrace, Camden-road, N.W.
Grote, Arthur, 42, Ovington-square, S.W.
Hobson, Richard, The Marfords, Bromborough, Cheshire.

The paper read was—

PREPARATION OF DRAWINGS FOR PHOTOGRAPHIC REPRODUCTION.

BY JAMES SHIRLEY HODSON, F.R.S.L.

Author of "An Historical and Practical Guide to Art Illustration."

Every object that is capable of producing an image upon the organ of vision is capable of being reproduced by photography, and therefore it is taken for granted that no special care need be exercised in the matter of the preparation of drawings for photographic reproduction. The camera is the magic lantern which is credited with the power of being able to "turn lead into gold," or of making an artistic picture out of a crude and imperfectly prepared design.

Such appears to be the prevalent belief, and it is only upon some such hypothesis that we can account for the disregard often evinced by artists as to the means to be employed in the preparation of drawings intended for photographic reproduction. If the successful preparation of such drawings were indeed one of the things that "come by nature," it would unquestionably be inferred that, in undertaking to lay before the members of the Society of Arts a paper devoted specifically to the consideration of this subject, I had set myself a task as unnecessary as it would be likely to prove unprofitable.

There is, however, ample evidence in support of the assertion that among artists there exists an apparent indifference to the means to be employed, or a want of knowledge of the principles involved, as well as a disregard of the technical application of those principles. I have seen sketches made in charcoal upon coarse brown packing paper, with the "high lights" put in with body white, and offered as designs suitable for conversion into relief blocks. Satisfactory as such sketches may be from an artistic point of view, they are valueless to the photographer. This is only one of the many difficulties which are presented in the production of those illustrated catalogues with which we are familiar under the title of "Academy Notes."

Although it may be frankly admitted that the subject which I have the honour of submitting to your attention to-night is neither extensive in detail nor abstruse in character, I hope to be able to show that it is at least interesting and useful.

There are two separate and distinct styles of drawing for reproductive purposes, whether the artistic engraver be employed, or any of the means of automatic engraving be used. These two methods are technically known respectively as *fac simile* drawing, and drawing in wash. The former consists in the sole employment of lines, in which the shading is to be produced as well as the outline of a picture. Every line and mark that is subsequently to appear in the engraving must be traced in the original. This description of drawing is applicable to wood engraving, to line engraving upon copper or steel, as well as to all the methods for automatically producing blocks for relief printing. The line method is also universally adopted by etchers in *intaglio*.

Drawings in wash are frequently employed for the purposes of wood engraving, and may be successfully reproduced in aquatint, in mezzotint, and in some methods of photographic reproduction.

In the early days of engraving the work of the artist or designer, as well as that of the engraver, was performed by the same individual. We read of the *niellatori* of Italy, and of the *karten-macherin* of Germany, as being the earliest engravers respectively in *intaglio* and in *rilievo;* but no mention is made, so far as I am aware, of any distinct class of persons wholly employed in drawing or making the designs, unless, indeed, the illuminators were so employed. Before the introduction of printing, engravers were sufficiently numerous to form a special guild or fellowship, and it is possible that they may have been indebted to the illuminators for the designs upon which they worked. Subsequently there sprang up a feeling of alarm and jealousy of the new invention of type printing, which induced the engravers to endeavour altogether to prohibit the use of wood engravings in books, as we read in the history of Zainer, the printer, of Augsburg. The printer therefore, thrown upon his own resources, was compelled to try his skill as an engraver, and make his own woodcut illustrations as well as he could. The earliest examples of *fac simile* drawing are to be found in the block books of the fifteenth century.

Albrecht Dürer (1471-1528) is a remarkable and well-known instance of the combination of artist and engraver in the same person. This was also the case with many others among the celebrated etchers, both of early and modern times, many of whom were painters first, and adopted etching as a ready means of reproducing their designs, for the purpose of a wider popularity.

Contemporary with Albrecht Dürer (who is credited by his biographer, Dr. Thausing, with being the discoverer of etching), a notable example of the separate study of engraving, apart from the work of the artist, is to be found in the case of Marc Antonio Raimondi (1488-1534). After copying the engravings of Dürer so successfully as to cause them to be sold as originals, Mark Antonio submitted himself almost exclusively to the guidance of Raphael, for the purpose of translating on to the plate the paintings of the great master. It is but natural to suppose that a marked improvement in technical detail would result from the separate study of the two occupations. The undivided energy of the engraver would be fixed upon the means of reproducing upon the plate the effects of the painting which he had undertaken to translate; while the artist, on the other hand, would, by his advice, assist the engraver to preserve the artistic effects of the original.

In noticing, however briefly, the combination of artist and engraver in the same person, the mind naturally reverts to the career of Thomas Bewick (1753-1828). It is customary to speak of the revival of wood-engraving in connection with this name, because the art, in Bewick's day, had fallen into a very low and crude condition; but it must be admitted that Bewick's early works at least were exceptional neither in character nor in quality. He is principally celebrated for his introduction of the "white line," by the use of which he more completely separated the principal figures of his pictures from the background. He also, by occasionally paring down the surface of his blocks, produced a softened effect in outline, or shading, when required to be graduated towards the high lights of his design, or to be vignetted. Bewick assisted the printer in causing the light parts of his pictures to recede by the mechanical contrivance of partially lowering the surface of the block.

The use of a "wash" in preparing drawings for the engraver was adopted by artists, in consequence of the facilities which are thus afforded for producing effective designs with the smallest possible outlay of time and trouble. It is reported of a celebrated artist in "black and white," who now occupies a deservedly high position as president of one of our artistic institutions, that in the short space of half an-hour he has been known to put upon a wood block such indications of a design as served the purpose of the engraver, in the production of an effective if not elaborate illustration. Although the artist alluded to is known to possess a facile pencil, it is manifestly impossible, in so short a time, to give anything like a carefully detailed *fac simile* drawing. The general tone of the various portions of the design was indicated by the wash, while a few masterly touches of the pencil guided the engraver in what is technically called the "drawing" of the subject. When we hear artists complain that their drawings have been spoilt by the engraver; that their figures have been caricatured, their choicest intentions ruined, the "work" cut away, &c., it might in justice be inquired, how has the drawing been prepared? I have no desire to defend the engraver at the expense of the artist, because I know that the accusation is, sometimes at least, justly made; but it is fair to point out that, in the case of a wood-engraving, the evidences as to the method of preparing the drawing are absolutely destroyed in the operation of engraving. There is another element which operates to lower the character of an illustration in the process of engraving, resulting from the desire to cheapen the work. However artistic may be the skill employed in the production of the drawing, the engraver is frequently tempted to consider the commercial rather than the artistic aspect of the question.

The greatly increased use of wash in preparing drawings has unquestionably raised the character of the work of the engraver, particularly in the matter of tint work, by throwing him upon his own resources; but it is at least open to question whether in so doing the peculiar genius of the wood-cut has not been to a great degree lost sight of. The most modern, and in its way the most perfect exhibition of the "wash-drawing" style, is to be found in the school of wood-engraving, which has its exponents in the American publications of the *Century Magazine* and *Harper's Magazine*. Popular as this style appears to be with many, it is extremely doubtful if it will be able to retain the high estimation in which it is now held, beyond the time generally allotted to the caprice of fashion. The *English Illustrated Magazine*, on the contrary, studies to preserve in the character of its illustrations a recognition of the true genius of the wood-cut.

Not unfrequently the work of transcribing a design to the wood-block for the purpose of engraving is performed by the aid of photography, a plan which offers the additional advantage of altering the size or scale of the subject to the requirements of the engraving.

Successfully to prepare drawings for photographic reproduction, it is essential that some knowledge should be possessed of the fundamental principles of photography, as well as an acquaintance with the capabilities of the particular process of reproduction which is to be employed. Thus, the material upon which the drawing is to be made should be of such a character as will yield a strong and well-defined contrast to the lines of the drawing; while the pigment employed for the drawing should be as black as can be procured. White Bristol board of fine surface, and the best Indian ink, meet these conditions. A blue-black does not form a desirable drawing medium, but the introduction of red or orange into the composition would serve to intensify the photographic image. To draw upon a dark orange-coloured paper with a pale blue-grey ink would be simply to disregard all photographic principles, for the photographic value of the paper and of the ink would be nearly equal, and the drawing would consequently be lost.

Uniformity of colour in the drawing is also desirable, and the artist should resist the natural tendency to express distance and to produce his effects by diminishing the intensity of colour in parts of his picture. From a drawing uniform in colour a satisfactory negative is obtained; but, in the other case, the photographer must estimate an average duration of exposure, and will rarely escape the dilemma of some portions being over-exposed, while others are comparatively undeveloped. This theory receives illustration from the fact that very good subdued effects can be obtained from well-executed pencil drawings, where this uniformity of colour is preserved. A longer exposure may be required, but every part of the picture will be equally developed.

To return to the matter of the paper used, colour is not the only important consideration. If the surface of the paper be irregular and coarse in texture, such as painters in water-colour delight in—although of Whatman's best Turkey mill—good results must not be expected. A negative, taken in the ordinary way, from a drawing made on such a material, would inevitably reproduce all the inequalities of the texture of the paper, to the manifest injury of the more delicate parts of the drawing. In reproductions from old prints or printed books, the condition and character of the paper present some of the greatest difficulties with which the photographer has to contend. The ridges in the surface of the paper cast shadows which are too faithfully reproduced in the negative. The employment of a diffusive rather than a direct light is the usual remedy, but the best way of dealing with the difficulty is that employed in the studio of the Autotype Company. The original is laid upon the floor under a strong light, and the camera is set at an angle of 45 degrees.

Mr. Alfred Dawson informs me that he inclines to the opinion, founded upon his extensive experience and untiring experiment, that it is desirable to get rid of the surface of the paper altogether, by covering it with a substance similar to an enamel.

We now come to a consideration of the peculiar character of the engraving process for which the photographic image is to be taken, as this knowledge will determine, in some measure, the method of preparing the drawing. For all the ordinary purposes of mechanical printing, whether by the copper-plate, the lithographic, or the typographic process, it is essential that the details and shading of a picture shall be presented either by lines or by a stipple or grain. The use of the line method gives the designation of "line engraving" to a well-known description of artistic engraving upon steel or copper, and is also employed in wood engraving; while the use of a grain is the characteristic of mezzotint engraving and stipple engraving, and especially of the two varieties of aquatint.

There are other methods of reproduction where these conditions are not essential, such as the Woodburytype process, and the stannotype, as well as the process which is known by the names of collotype, heliotype, and Alberttype.

Wash drawings would appear to be inadmissible for reproduction by photography where the ultimate destination is the ordinary printing press, because the gradations of tone produced in a photographic print afford no resting place for the ink in printing. There are, however, methods by which an artificial grain or a line tint can be added photographically to the printing surface. The late Mr. Walter Woodbury was the first to meet the difficulty by interposing a gauze in the camera between the object and the negative. In Miessenbach's process a transparent plate is introduced for the purpose; and Ives's method of producing the same effect is said to be by means of a plaster cast. In all these methods of producing a system of lines through the picture it is very difficult to guard against the tendency of the lines to obliterate the drawing, and the effect is like looking at the artist through a gridiron.

There are in the market some specially prepared papers for drawing upon for photographic reproduction. The surface of the paper is smooth, and is coated with a composition upon which a series of lines or ridges is produced, so that, as the pencil passes over the paper, a serrated line is produced which greatly assists in the representation of the middle tones of a picture. Strong shadows are put in with Indian ink; and the effect of the high lights is produced by scratching away the surface of the paper.

Something has yet to be said as to the scale to which to make drawings intended for photographic reproduction. Drawings that are made of a larger size than the proposed resultant block, and have consequently to be reduced in the camera about one-fourth, generally produce satisfactory results. Artists adopting a bold treatment of their subjects may with advantage make larger drawings, but a limit of twice the scale of the intended printing surface should rarely be exceeded. Where the "lined clay paper" is used, the scale of the lines necessarily imposes a limit as to enlarged size of the drawing. If this be made on too large a scale, a reduction that would be suitable for the drawing would contract the distances between the lines so much as to present a confused mass.

There is yet another mechanical "aid to drawing" which requires to be described, as affording the means of facilitating the work of the artist. "Day's shading and printing medium" offers to artists a similar economy of time and labour to that of "wash drawing," as compared with *fac simile* work. The outline of the drawing being made, all the drudgery of the shading can be added by means of "Day's shading mediums." The patent claims to secure the "method of lining, shading, stippling, hatching, graining, printing, or tinting pictures or other objects in one or more colours, which consist in applying pressure to the back of a printing film, having an inked printing face in relief." The drawing being made in outline, a suitable film is selected, and after being inked on the under surface and placed in position, a burnisher applied on the upper surface fills in the shading required. The shading mediums can be used on drawings made on paper or other material, and on lithographic stones or zinc.

In conclusion, the conditions required in the successful preparation of drawings for photographic reproduction may be thus briefly summarised:—

That a sufficient photographic contrast should exist between the pigment employed and the material upon which the drawing is made.

That a paper should be selected which is smooth and without water-mark, and white.

That the drawing material may be pencil or ink, in which blue is not a component.

That the drawing may be advantageously made upon a larger scale than the intended result.

That a line or *fac simile* drawing is preferable where a relief block is required, and that a uniformity of colour in the drawing should be aimed at.

That the wash method may be freely employed in drawing for any of the gelatine processes, including photogravure, collotype, Woodburytype, &c.

At the conclusion of the paper specimens of the work produced by Mr. Day's shading and printing medium were shown.

The paper was illustrated by a series of framed prints which were hung on the walls, and exhibited by Messrs. Boussod, Valladon, and Co., successors to Messrs. Goupil (specimens of photogravure), Messrs. Waterlow and Sons (photo-prints compared with the original drawings), the Autotype Company, Messrs. A. and E. Dawson, the Phototype Company, the Automatic Engraving Company, Messrs. Sprague and Co. (specimens of their ink process), Mr. C. Hancock (drawings, copies, and blocks), Mr. Shanks, and Mr. Dallas.

DISCUSSION.

Mr. BIRD said the scope of the paper was rather limited, and did not give much room for discussion; but Mr. Hodson had stated the principal facts, which artists would do well to bear in mind, if their work had to be reproduced by photographic means. In the great majority of drawings, whether in chalk or washes, the tone of the paper would operate prejudicially if they were reproduced in the camera. A pencil drawing might be extremely effective and satisfactory in effect on a toned paper, and the lines of such drawings might be faithfully reproduced, but the half-tints would be spoiled, owing to the effect of the surface of the paper, and though the lines might be perfectly rendered, the effect of the tone of the paper would be entirely lost. It was very desirable that some one should take up the subject experimentally, and try all the usual kinds of artists' materials, oil and water colours, chalk, pencil, different kinds of papers, and other expedients. In that way they would soon arrive at the best paper, the best pigments, and the best method.

Mr. H. TRUEMAN WOOD thought the paper had hardly done justice to the extent to which photography would be used in the future, in the preparation of illustrations either for books or on a larger scale, such as were shown on the walls. There were three classes of drawings to the reproduction of which photography might be applied, drawings in line, sketches in monochrome, and coloured pictures. From any one of these originals it was possible to produce a print, by lithography, by the use of an intaglio plate, such as a copper-plate, or by the use of a surface block which could be printed with type. Besides this there were the processes for producing prints in half-tone, such as the Woodbury type and Collotype. The process of reproducing a picture already in line was tolerably simple, and had been dealt with sufficiently in that room, in Mr. Bolas's Cantor lectures, and in other papers. A line engraving, a wood-cut, a pencil drawing, or an etching could be reproduced with great ease in photography, and either printed in lithography, or a block might be prepared to print with ordinary type. He shared the opinion which he knew was held by many well able to judge, that there was a very great future for photography in reproducing illustrations of that sort; and every day processes were coming more and more into use, not only for book illustration, but even in many of the illustrated papers. The files of the *Graphic* and *Illustrated London News*, for instance, would show that process blocks were coming extensively into use for such purposes. To produce printing surfaces from monochrome pictures was more difficult, but it was now being regularly done, and he was quite certain that, before long, people who wanted illustrations made would not be satisfied with depending on the skill of the engraver to reproduce the artist's intentions, but in all cases where real accuracy of reproduction was required would insist on having an actual photograph, either from the object itself or from the artist's drawing reproduced as a printing block. In the case, for instance, of a traveller in a new country, it was of very great importance that the pictures he had taken—and no traveller should dream of going into a new country without a camera—should be reproduced as evidence of what was actually seen, rather than trusting to what an artist thought he saw, or what an engraver thought the original artist saw. In looking at Lieutenant Greeley's recent work on the Arctic regions, he had been much struck with the illustrations of arctic travel, as showing what could be done by photography. In this case the illustrations were not reproduced directly on the block by photography, and had to be translated into line by the skill of the engraver, but the photograph guaranteed the fidelity of the outline at any rate; these illustrations were as good as could be desired, and bore evidence that what appeared in the book was actually what was before the camera when the picture was taken. Those interested in the subject knew perfectly well the processes by which blocks were produced from wash sketches, such as the processes of Meissenbach and others, and he need not describe them, but he did think Mr. Hodson had been scarcely fair to Mr. Ives, in saying that his process "was believed to be carried out by means of a plaster cast," for Ives had described in his specification most exactly all the details of the process, so that anyone could take the specification and go to work, and if he had sufficient skill could produce a block himself. This was more than could be said of the majority of patented processes, the specifications of which were, generally speaking, very deficient indeed in information. He believed the time was not far distant when the majority of our illustrations would be produced by the artist making a drawing in wash, having that photographed, and reproduced by one of the many processes for introducing grain into the drawing, so as to make it capable of holding ink, and being printed. In the case of the reproduction of coloured pictures, he thought they might have had a reference to isochromatic plates, by means of which pictures could be much more faithfully translated into a photograph than by the ordinary mode. Some very interesting accounts had lately been given at the Photographic Society of the way in which this was done, and no doubt Captain Abney could give some further information about it. He would also refer to the excellent instructions given by Colonel Waterhouse in the *Photographic News* for 1882, page 482, which he prepared for the Indian Survey, as to the way in which drawings that were to be copied by photography should be prepared. Colonel Waterhouse had principally in view the reproduction of maps, and therefore said nothing about wash drawings; but the instructions he gave would be found very useful by those who had work of that sort to do. He thought Mr. Hodson must have made a slight mistake in saying that the Autotype Company copied pictures placed on the floor, by pointing the camera at an angle of 45 degrees, as he could not see how anything but a curiously distorted image could be produced in that way.

Mr. ALFRED DAWSON said he would confine his remarks to the question of letter-press illustration, for the works of Goupil and others of a similar class were so full of technical details and elaborate working-up that they hardly came within the scope of the paper. It was very important that the artist and the man of science should know what to expect—what could be done, and what ought to be done. One point which he could say, as an artist as well as a photographic reproducer, had been entirely forgotten up to the present time, was that the facility of the artist's hand lay at the root of all the work which could be done. If the artist had to work in an awkward manner he was handicapped, and his work when done would not be worth printing, or at any rate, it would not be what it should be. Therefore, any process should be judged of in the light of the question, "Did it cramp the artist?"—and if it did, it must be improved until that objection was removed. There were very nice methods which would reproduce a very good result from another photograph, or from nature, but the public would soon tire of any kind of reproduction of that sort, because such pictures had no soul in them. When the public bought a book full of pictures they wanted the reproduction of a man's mind and thought; the touch and feeling of the artist therefore lay at the bottom of all reproductive processes, and in that view there were one or two points to be considered. He had seen printed instructions that a line drawing should be perfectly clear, in black and white, but there were exceptions to that. The late Mr. Cecil Lawson used to make a kind of drawing which always came out splendidly, but he had no idea he was doing anything particular. He took the upper end of a pen, or a half-dry brush, and rubbed the ink about the paper until he produced a sort of tint, and in that he worked his lines, and produced that dark effect of which he was so fond, but those drawings always came out first rate. That showed you wanted something more than a clear outline, and when an artist wasted a deal of trouble in making a nice clear line drawing, it often turned out wiry. The printing ink did not give the same effect as was produced with the pen; sometimes a thick line became almost thin, and the work turned out unsatisfactory. There was a kind of pen work on rough paper, in which the line was broken up into dots, in which this fault was cured. Again, sometimes thin lines became thick, and perhaps not one block in a dozen, even when drawn in clear lines, would come out as it should. Mr. Pennell drew with a very black shiny ink which reflected the light, so that when photographed the lines were filled with little dots, and that destroyed the effect because you could not go over all the lines and make them solid, and when photographing by the electric light in dark weather this evil was intensified. There were several good printing methods, but none touched the point he had referred to. Some of Goupil's works showed the artist's efforts actually reproduced, but when would that be obtained in letter-press printing? The American engravers had to a large extent succeeded in doing so, but it would be a long while before any "process" would give similar results. The method of Messrs. Sprague, though not a letter-press process, could be converted into a block, and that was the nearest approach he had seen to an actual reproduction of the artist's work. The artist must not be hampered but developed, and in his mind's eye he could see the artist's drawing exactly reproduced before the public. If there were a tree with a stump nearly black, that should come out, and so should the effect of scattered sunlight. The last point was the printing, and there the question of cost came in, because to produce the best effects not only must the very best skill be employed, but paper of the very finest quality. What was very satisfactory for a rough sketch like the Academy notes, was not at all the thing for a standard work, to hand down the result of skill and genius to all ages.

Mr. HANCOCK said pencil drawings could never be expected to come out satisfactorily in photography, because every grain of blacklead was a small mirror, which reflected the light. For line drawings, if drawing paper were used, drawing ink should be employed; if on smooth writing paper, writing ink should be used, and then the result would be satisfactory. A very good result would be obtained by drawing with Indian ink on drawing paper, if the lines were all of the same colour.

Mr. WARNERKE said he had tried the grained paper to which reference had been made, and found it very useful. It gave the appearance of a very elaborate drawing, with a very delicate grain, just what was wanted for a photograph, with very little trouble. This paper was used largely on the Continent, and almost all drawings intended for photographic reproduction were made on it. There were several kinds. One consisted of parallel lines in relief, the paper itself being white; in another kind the parallel lines were impressed in the paper; and in a third there were black lines printed perpendicular to the first. When you made a shade with the pencil on this paper the result was a series of square points, but when you used a penknife you got a network of lines. In this way you could produce a variety of effects which were very well reproduced in the photograph. The most suitable pencils to use with this paper were those made by Hardmuth, marked "Negro," made in five degrees of hardness, No. 1 being the softest. They were perfectly black, rather greasy, and took kindly to the paper. He was of the same opinion as Mr. Wood, that before long no process except photography would be used for making printing blocks, which would soon rival the more costly methods of engraving.

Mr. WERGE said with regard to obtaining a photograph of an object placed on the floor, it could either be done by turning the camera upside down, as he had done to photograph objects, such as carved ivories, which could not be hung up, or by placing the camera at an angle and using a reflector. With regard to the isochromatic plates alluded to by Mr. Wood, he could not say that he was perfectly satisfied with them; they reproduced the yellows better, but they did not recognise the reds at all; and as Mr. Sawyer, of the Autotype Company, proved, even the yellows were not recognised in their proper proportion. He gave an instance of three different shades of yellow being photographed with these plates, and they gave exactly the same tint to them all. The remarks hitherto made applied chiefly to drawings copied by the camera, but his experience was that if the drawings were made on translucent paper, whether pen and ink, pencil, wash drawings, or any form of monochrome, they were best copied without the aid of a camera at all; simply by contact printing. Of course this could only be done where the copy was of the same size as the drawing, but even if an enlargement or reduction were required, a better result would be got by making a transparency from a negative so obtained. When this method was resorted to, the roughness of the paper was of very little consequence. Not long ago he had replaced a lost calotype negative in this way to complete an interesting series of old architecture. He happened to have an old silver print of the subject, which he simply laid in contact with a dry plate, and obtained a negative, which, with the original and a print from it, he had brought with him; it was a perfect *fac simile* of the original, except in colour. In the old wet plate days this could not be done, because you could not put anything in contact with a wet plate without ruining it, but now the most valuable drawings could be placed in contact with bromised paper, or a gelatine plate, and reproduced without the slightest risk or injury.

Captain ABNEY, F.R.S., said he was in hopes that the day would not come when all book illustrations would be produced by photography because, as Mr. Dawson had said, the great pleasure of a good illustration was the soul put into it by the artist. He must differ, however, from Mr. Dawson on some of the technical details he had gone into, such as the spreading of lines, for instance. He had had some experience of these processes, and if they were perfect, none of this spreading or wiriness ought to appear. The result ought to be an exact reproduction of what the artist had put on the paper. There were difficulties, no doubt, but he had seen *fac similes* which it would be difficult to distinguish from the original. He also thought the difficulties connected with rough paper had been exaggerated. He had had to photograph hundreds of drawings made on very rough paper, and could only say that when once you knew how to get over the difficulty it disappeared for ever. You were not supposed to have the very exact exposure which was necessary to reproduce a half-tint negative, but you could get rid of the grain by giving a very reduced exposure, and placing the print in a proper light. If the artist would use moderately smooth drawing paper, so much the better; but if he preferred to use rough, it did not matter, the drawing could still be produced. Mr. Werge recommended contact printing, but he did not think it was to be compared to printing in the camera. The very excellent negative he had shown would, he thought, have been produced better in the camera. Mr. Baden Pritchard reproduced by contact printing, long before gelatine was thought of, a great many of Roger Fenton's photographs taken in the Crimea. He used the collodio-bromide process, and the result did great credit to his ingenuity. With regard to pencil drawings, as had been remarked, every piece of graphite from a pencil was a reflector. Glass reflected light, although it was not silvered at the back, and so did graphite; in other words, it was transparent, and if you made a hard stroke more was employed and it was less transparent, whilst a light stroke was more transparent. There was white shown through the light strokes more than through the dark strokes, and therefore, by any method of block printing or lithography, it was absolutely impossible to reproduce a pencil drawing in correct gradations of tint. He had copied a great many pencil drawings, and always found this was a difficulty. The artist used his pencil with different degrees of pressure, and so produced gradations of light and shade. It was really a half-tint picture, drawn in line, and therefore it could not be reproduced so perfectly as a pen and ink drawing. It was rather too late to go into the question of isochromatic (or, more properly, ortho-chromatic) plates, but he thought Mr. Werge had spoken too strongly against them. Even since Mr. Sawyer read his paper, considerable strides had been made in reproducing coloured pictures in correct gradation of tint. In a coloured drawing there were three things to be taken account of—first of all the colour itself, whether it were pure; next the line; and, thirdly, the luminosity of the colour. You could not imitate the line, you could only hope to imitate the luminosity in black and white, and it was perfectly easy to judge whether the luminosity of black and white, or of any particular grey, was the same as that of any particular colour on a picture, and the process of orthophotography, as he preferred to call it, had advanced to such an extent that he believed it now even represented the three shades of yellow, which it could not do at the date of Mr. Sawyer's paper.

Mr. ARCHER CLARKE said he was very glad to hear Mr. Werge say a word in favour of contact printing. He had just had a number of photographs brought in by a gentleman to be copied, which had come from Italy, and he said he could only leave them for an hour and a-half. Of course it was impossible to reproduce them in the camera in that time; the only way was to put them in a printing frame and expose them under the gas with photographic sensitised paper. The whole twenty were taken off in about 75 minutes, the photographs were returned in exactly the same condition as they were received, and now any number of copies could be reproduced by lithography or any kindred means. With reference to pencil drawings, he had no doubt they had all seen the windows full of copies of Frank Miles's drawings, including the "Gardener's Daughter;" they were the perfection of reproduction, and they were all from pencil drawings.

The CHAIRMAN having moved a vote of thanks to Mr. Hodson, which was carried unanimously,

Mr. HODSON, in reply, said he had, in preparing his paper, kept strictly within the title, and had considered that any observations on the means of reproducing drawings after they had been prepared would be outside the subject. He mentioned that in reference to the observations which had fallen from Mr. Wood. He was very much interested in the subject, and was no doubt echoing the opinion of others when he said that the discussion had been particularly interesting and instructive.

Miscellaneous.

COLONIAL AND INDIAN EXHIBITION.

The first meeting of the Reception Committee was held on Wednesday, March 31st, at the House of the Society of Arts. There were present:—The Duke of Abercorn, C.B. (Chairman); the Earl of Cadogan (Vice-Chairman); the Right Hon. the Lord Mayor of London; Sir Daniel Cooper, Bart., K.C.M.G.; Sir Charles Tupper, G.C.M.G., C.B.; Sir Selby Smyth, K.C.M.G.; Sir Charles Hutton-Gregory, K.C.M.G.; Sir John Coode; Samuel Morley, Esq.; Field-Marshal Lord Napier of Magdala, G.C.B., G.C.S.I.; Major-General Sir Peter Lumsden, G.C.B., C.S.I.; Lieutenant-General Sir Charles Brownlow, K.C.B.; Lieutenant-General Sir Samuel Browne, K.C.B., K.C.S.I., V.C.; Lieutenant-General Sir Harry Lumsden, K.C.S.I., C.B.; Colonel Sir Owen Tudor Burne, K.C.S.I., C.I.E.; Sir Philip Cunliffe-Owen, K.C.M.G., C.B., C.I.E. (Secretary to the Royal Commission); Arthur Hodgson, Esq., C.M.G., General Secretary, and Lieutenant-General Henry K. Burne, C.B., and H. Trueman Wood, Esq., Secretaries. This committee has been appointed by H.R.H. the Prince of Wales, to make arrangements for the reception of Colonial and Indian visitors to the Exhibition. One principal duty of the committee will be to organise visits to manufacturing towns and other centres of interest, and to arrange that special facilities are provided for visitors anxious to see as much as possible of the country in the limited time likely to be at their command. In order to defray such charges as may be required for the proper carrying out of the scheme, the committee has been authorised to collect subscriptions from those who may wish to take part in a movement of this national character. The Society of Arts has consented to afford the use of their house and their organisation in aid of the scheme, and it is believed that the committee may reckon on receiving valuable aid from the provincial corporations, while it is hoped that in many cases the mayors of the chief seats of industry will receive the visitors and arrange for their being hospitably entertained during their stay. At their meeting on Wednesday, the committee considered generally the arrangements which might be made for the reception of the numerous distinguished visitors who may be expected to visit this country during the coming summer, and appointed a sub-committee to prepare a detailed scheme on the lines suggested.

WORKMEN'S CLUBS.

In the number of this *Journal* for February 19th (see *ante* p. 307), a short account was given of the scheme of Workmen's Clubs which has been organised in connection with the Exhibition. The following supplementary notes may now be added.

The clubs are invariably composed of a president, a number of vice-presidents, an honorary secretary, and a number of suitable representatives as committee-men, in addition to honorary members and ordinary members. Honorary members are those who give donations to the clubs for the purpose of assisting deserving members of the working classes. Grants of assistance, from these sources, will be made entirely at the discretion of the local committees.

Until September, members of these clubs may subscribe small sums (the amount of which is at the discretion of the various local committees) with a view to forming a fund to defray the expenses of their stay in London and their journey to and fro. No person can be admitted to club membership after the 18th of September.

The railway companies of the United Kingdom have, in compliance with a special request made to them by H.R.H. the Prince of Wales, agreed to accord considerable privileges in regard to travelling facilities to the members of the clubs.

From the 21st June next, until the 31st October, members of the clubs will be able to secure—on presentation of a warrant (copies of which will be supplied to the local committee by the Royal Commission) at the booking offices of their respective railway stations—a ticket to and from London for the price of a single third class fare. Tickets will be granted to children under twelve years of age at half the price to be paid by adults. These tickets will be available for return for any number of days up to fourteen from the date on which they are issued. The only condition imposed upon members is that they shall have joined the club not less than six weeks previous to the date of the issue of their warrant.

It will thus be seen that any working-man who desires to avail himself of the privilege of membership at the earliest date (21st June), will be able to do so, even if he joins the club as late as the first week in May. It should, however, be pointed out that subscriptions if commenced at an earlier date, would necessarily be smaller than would those confined to the exact six weeks. The responsibility of deciding what classes of persons resident within the locality should be admitted to club membership rests entirely with the local committee; but, as a general rule, it is suggested that persons of every class of life, who may be in the receipt of weekly or monthly wages, should be deemed eligible for membership. It should be further noted that a man may make his wife and any number of his children members of the club. Single women may also become members.

The local committees will be supplied by the Royal Commission with copies of a list of all respectable small hotels, lodging-houses. and eating-houses (with their respective tariffs), the proprietors of which may be disposed to offer accommodation to club members on favourable terms.

Where members of a club think fit to form themselves into parties of not less than five in number, the Royal Commission will arrange for the supply of trustworthy guides at a charge of about five shillings a day. The larger the party, the less, naturally, will be the expense to each member. Notice will have to be given not less than a week previous to the day upon which the party sets out upon its journey. The terms will then be intimated; and, when accepted, the guide will be instructed to meet the party by whatever train it decides to reach London.

Every member of a club will be entitled to receive from his local committee, on payment of sixpence, an admission to the Exhibition, and printed particulars, which will aid him in a thorough examination of the objects in the Exhibition.

In obedience to the instructions of H.R.H. the Prince of Wales, Mr. Somers Vine, the official agent to the Royal Commission, has within the last few weeks attended and addressed public meetings, called together to discuss the club scheme, at the following towns:—Newcastle, Carlisle, York, Scarborough, Bridlington, Liverpool, Radcliffe, Northwich, Spalding, Wisbeach, Bournemouth, Bristol, Bridgewater, Wells, Taunton, St. Thomas's, and Exeter.

In most cases, resolutions in support of the scheme have been enthusiastically carried. And it should be stated that in many other towns, where the Royal Commission has not been represented, meetings have been called, and clubs have been formed.

At the meeting of the Court of Common Council, on Thursday, April 1, a letter was read from Mr. Francis Knollys, C.B., private secretary to the Prince of Wales, addressed to the Lord Mayor, in which his Royal Highness expressed his extreme gratification at the guarantees given by the Corporation and the City Companies to the Exhibition, a work which he believed would be of vast importance, not only to our Indian Empire and Colonial dependencies, but to the inhabitants of the United Kingdom.

BOTANICAL GARDENS, NILGIRIS.

The Report of the Director of the Government Botanical Gardens and Parks for 1884-5, has been received from the India-office, and the following notes on some of the more interesting plants, which have been introduced or grown in the gardens during the year, is taken therefrom:—

Erythroxylon Coca.—Two big bushes of this plant exist at Barliyár, where they grow freely, but fruit sparingly. About sixty young plants have been raised from seed, and a large number of cuttings were put down during the winter, but these have not done well. It may be taken as certain that *Erythroxylon coca* will thrive well in many parts of Southern India, and that it may be easily propagated from seed, but that it will be profitable for the European planter to grow it upon a large scale is a matter upon which I entertain much doubt. Vast tracts of country in South America are cultivated with this plant, and an almost unlimited quantity of leaves may be obtained from that country for the purpose of manufacturing the valuable alkaloid *Cocaine.* Last winter this alkaloid is said to have fetched 2s. 6d. per grain. At this price, could it have been maintained, its cultivation would have been productive of enormous profits, but the price has since declined to 7d. per grain, and it is very unlikely that this sum will be realised much longer. In this opinion Mr. Thiselton Dyer concurs, and he moreover wrote a short time ago to caution me against being too sanguine that the cultivation would be a commercial success, or advising me at any rate to discount very largely the reports which had been spread abroad about it.

Mr. Hooper has analysed three samples of the leaves taken from the bushes at Barliyár. In his first attempt to isolate the alkaloid in a crystalline state he was unsuccessful; in his second attempt he succeeded in obtaining the alkaloid as crystalline, but with an admixture of some acrid principle which rendered it useless as an anæsthetic; his third attempt ended in complete success, and the alkaloid manufactured by him has been used and approved of by Dr. Brockman in his surgical ophthalmic operations. Surgeon-General Doctor Furnell reports that the simple chewing of the leaves is productive of relief in cases of spasmodic bronchial coughs, and suggests that *Cocaine* should enter into the composition of cough lozenges. Mr. Hooper's analyses show that the leaves of the bushes grown at Barliyár are very rich in the alkaloid, as he extracted from them ½ per cent.

Erythroxylon monogynum.—The leaves of this plant are said to have been largely eaten during the famine by the natives of several districts where it grew wild in abundance, and it was thought probable that the leaves of this plant might be found to contain an alkaloid with properties similar to that which is obtained from the *Erythroxylon coca;* and Dr. Cornish just before he left India wrote to ask me to have the subject investigated. As the plant does not grow upon these hills, I applied to Mr. Gamble for his assistance, and he has sent me several small consignments of the leaves, which had been collected and dried by Mr. Higgins, Deputy Conservator of Forests in the Cuddapah District. These consignments I handed over to Mr. Hooper, who, after his analyses of them, reports that they ontain no anæsthetic property at all analogous to that which is found in *Erythroxylon coca;* but that they do contain a bitter and a tonic principle which may have mitigated the pangs of starvation.

Eucalyptus Globulus and other species.—During the year 20 lb. of the oil of the leaves of the *Eucalyptus globulus* were sent to the Madras Medical Department. The latter consignment was sold at the rate of Rs. 3-3-0—5 shillings per pound being the wholesale English quotation.

The processes required for the manufacture of the oil are very simple and inexpensive, and I think it is a pity that those who have large plantations of these trees should not endeavour to utilise them for this purpose as well as for fuel. The way to extract the oil is as follows:—

The young shoots, having perfectly matured but not old leaves, are passed through an ordinary chaff-cutter and cut into slips not exceeding one inch in length; the smaller the chips the more readily is the oil extracted from them. These chips are then macerated in water over night and put the next morning into a still, which is kept boiling, till the greater part of the fluid has past over as vapour. This is then shaken up with a little common salt to cause the complete separation of the oil from the water; the oil is then decanted from the water and passed through a sheet of filtering paper, when it is ready for sale.

Instead of passing the leaves through a chaff-cutter, it would be better to pass them through some crushing machine, as the object is to smash up the hard cells, which surround the cavities into which the oil is passed by the secreting cells. I do not know of such a machine, but I should think that some modification of the old-fashioned mangle would prove effective.

Box.—This at an elevation from 5,000 to 7,500 grows more vigorously than I have ever seen it do in Europe, and I have planted a small plot of ground near the jail on the Dodabetta estate with the view of finding out if it may not be profitably grown to supply the wood engraver's trade.

Castilloa elastica.—The few plants of this rubber-yielding tree, which were put out two years ago at Barliyár, are growing grandly.

Ceara.—This fruits freely at Barliyár, and the seed appears to be eaten by birds and deposited in the neighbouring jungle, for young plants have been found growing where they never had been planted by man. If this is so, we may look forward to the Ceara rubber tree becoming a denizen of our ghât forests.

Waras.—I was asked last year by Mr. Thiselton Dyer to obtain information for him about this dye. This I have done, and from specimens which I sent to Kew *waras* turns out to be the produce of *Flemingia Grahamiana F. congesta.* With respect to the distinctive characters of these two species, I pointed out that, after studying the plants in their living condition, I did not think them sufficiently constant to allow of the two species being kept separate, and in this opinion both Mr. Thiselton Dyer and Professor Oliver now concur. The *waras* yields a beautiful dye when applied to animal substances such as silk or wool, but it is inferior as a dye when used for the purpose of colouring vegetable products, such as cotton or linen. Mr. Thiselton Dyer has kindly obtained for me a London expert's opinion upon the value of *waras*, and I regret to say that it is not such as is likely to lead one to believe that it will ever become an object of commercial interest. I may mention that when I was in Madras last winter, I saw at the Agri-Horticultural Garden's flower-show a specimen of *waras* in a native dyer's collection which was being exhibited, and from which it would appear that *waras* is not unknown as a dye in India.

Obituary.

EDWARD SOLLY, F.R.S.—By the sudden death, from heart disease, of Mr. Edward Solly, on Friday 2nd inst., the Society of Arts loses one of its oldest members, and one who held the office of Secretary at the period this *Journal* was first started. Mr. Solly was born in London on October 11, 1819, and was educated at Berlin. He was elected a member of the Society of Arts in 1838, and in the same year he was appointed Chemist of the Royal Asiatic Society. In 1841, he was Lecturer on Chemistry at the Royal Institute, and Hon. Member of the Royal Agricultural Society in 1842; in 1843, he was elected a Fellow of the Royal Society. In 1845, he was appointed Professor of Chemistry in the East India Company's Military College at Addiscombe; and in the following year Hon. Professor of Chemistry to the Horticultural Society. His work on "Rural Economy," first published in 1843, was issued in a third edition in 1850. The Royal Society's catalogue of scientific papers contains the titles of a series of twenty-two papers on subjects connected with chemistry, physics, and agriculture, written by Mr. Solly from 1836 to 1849. His first paper on the "Conducting Power of Iodine, Bromine, and Chlorine for Electricity" was published in the "Philosophical Magazine," in 1836, and was translated into German, the translation appearing in the journals of Erdmann, Liebig, and Poggendorff. He delivered in 1852 one of the lectures on the results of the Great Exhibition, his subject being vegetable substances. On June 9, 1852, Mr. Solly was appointed secretary of the Society of Arts, he having previously resigned his seat on the Council and membership of the Society. On May 4, 1853, he resigned his office, and was succeeded in July by the late Mr. Le Neve Foster. Since that time Mr. Solly's studies were more especially devoted to English literature, and he became one of the greatest authorities on questions respecting the period of Pope and Swift. He was a frequent contributor to the *Notes and Queries*, the *Bibliographer*, *Antiquary*, &c., and was one of the founders of the Index Society, for which Society he compiled a valuable "Index of Hereditary Titles."

MEETINGS OF THE SOCIETY.

ORDINARY MEETINGS.

Wednesday evenings, at Eight o'clock :—

APRIL 14.—"The Treatment of Sewage." By Dr. C. MEYMOTT TIDY. Sir FREDERICK ABEL, D.C.L., C.B., F.R.S., will preside.

FOREIGN AND COLONIAL SECTION.

Tuesday evenings, at Eight o'clock :—

APRIL 13.—"The Progress of the British Possessions in the last quarter of a century." By P. L. SIMMONDS.

MAY 6.—"The Commerce and Industries of New South Wales." By EDWARD COMBES, C.M.G., President of the Board of Technical Education of New South Wales. Sir HENRY BARKLY, G.C.M.G., K.C.B., F.R S., will preside.

APPLIED CHEMISTRY AND PHYSICS SECTION.

Thursday evenings, at Eight o'clock :—

MAY 13.—"The Scientific Development of the Coal Tar Colour Industry." By Professor R. MELDOLA, F.C.S.

INDIAN SECTION.

Friday evenings, at Eight o'clock :—

MAY 7.—"Indian Manufactures from a Practical Point of View." By B. H. BADEN POWELL, C.I.E. The Right Hon. Lord HARRIS will preside.

MAY 21.—"Everyday Life of Indian Women, as revealed in their own sayings." By Capt. RICHARD CARNAC TEMPLE.

The above dates are liable to alteration.

CANTOR LECTURES.

The Fifth Course will be on "The Arts of Tapestry Making and Embroidery." By ALAN S. COLE.

Lecture II.—April 12.—Classical allusions to Decorated Hangings—Method of making Tapestries compared with that of simple Weaving and Carpet-making—Textiles of Græco-Egyptian, Turcomar, modern Japanese—Indications of Commerce, Craft-Gilds, and organised Factors during 1st to 12th Centuries in Europe, Syria, Persia—Application of the Tapestry-making Process to Hangings—Antiquity of use of Hangings—Decorated Textiles used in 11th and 12th Centuries—Bayeux Tapestry—Tapestry from St. Gereon, at Cologne—Scheme of its Pattern compared with that shown in Sassanian Metal-work—Sicilian Weavings—Italian and Icelandic Embroideries—Early mentions of Tapicers and Tapissiers—Patronage of the Burgundian Dukes—Influence of Flemish Paintings upon Designs in 14th and 15th Centuries—Spread of Tapestry-making in other European Countries—Petrarch's Triumphs in Books, Furniture, and Tapestries of the late 15th and 16th Centuries—Tapestries in 17th Century—Gobelins—Mortlake—Résumé.

Additional Lectures.

Six Elementary Lectures on "Electricity" will be delivered by Professor George Forbes, on Saturday afternoons, at Three o'clock:—

Lecture II.—April 10.—Currents and Resistance.
Lecture III.—May 1.—Magnetism.
Lecture VI.—May 8.—Electro-magnetic Phenomena.
Lecture V.—May 15.—Induction.
Lecture VI.—May 22.—Electrical Measurement.

Tuesday evenings, at Eight o'clock:—

"Japanese Art Work." By Ernest Hart.

Lecture I.—May 4.—Japanese Metal Work.
Lecture II.—May 11.—Japanese Porcelain and Pottery.
Lecture III.—May 18.—Japanese Picture Books and Drawings.

MEETINGS FOR THE ENSUING WEEK.

Monday, April 12...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. (Cantor Lectures.) Mr. Alan S. Cole, "The Arts of Tapestry-making and Embroidery." (Lecture II.)
Geographical, University of London, Burlington-gardens, W., 8½ p.m. Capt. Cyprian A. G. Bridge, "Cruises in the Western Pacific, including visits to the Caroline and Marshall Islands."
British Architects, 9, Conduit-street, W., 8 p.m.
Medical, 11, Chandos-street, W., 8½ p.m.

Tuesday, April 13...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. (Foreign and Colonial Section.) Mr. P. L. Simmonds, "Progress of the British Possessions in the Last Quarter of a Century."
Royal Institution, Albemarle-street, W., 3 p.m. Professor A. Gamgee, "New Function of Circulation." (Lecture VI.)
Medical and Chirurgical, 53, Berners-street, Oxford-street, W., 8½ p.m.
Civil Engineers, 25, Great George-street, S.W., 8 p.m 1. Adjourned discussion on Dr. Percy F. Frankland's paper, "Water Purification; its Biological and Chemical Basis." 2. Mr. Henry Ward, "Brickmaking."
Royal College of Physicians, Pall-mall East, S.W., 5 p.m. (Lumleian Lecture.) Dr. W. H. Stone, "The Electrical Conditions of the Human Body." (Lecture II.)
Photographic, 5A, Pall-mall East, S.W., 8 p.m.
Anthropological, 3, Hanover-square, W., 8 p.m. 1. Mr. H. Ling Roth, "The Origin of Agriculture." 2. Dr. Hickson, "Notes on the Sengirese."
Colonial Institute, St. James's Banqueting-hall, 69, Regent-street, W., 8 p.m. Mr. Nevile Lubbock, "Our West Indian Colonies."
Horticultural, South Kensington, S.W., 1 p.m. Promenade Show.

Wednesday, April 14...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. Dr. C. Meymott Tidy, "The Treatment of Sewage."
Hospitals Association (at the House of the Society of Arts), 5 p.m. Second Annual Meeting.
Graphic, University College, W.C., 8 p.m.
Microscopical, King's College, W.C., 8 p.m. Mr. G. Masree, "Structure and Evolution of the Florideæ."
Pharmaceutical, 17 Bloomsbury-square W.C., 8 p.m.
Royal Literary Fund, 10, John-street, Adelphi, W.C., 3 p.m. Annual Meeting.
Naval Architects (at the House of the Society of Arts), noon. Annual Meeting. 1. Opening Address by the President. 2. Reading of papers and discussions.

Thursday, April 15. Naval Architects (at the House of the Society of Arts). Annual Meeting. Morning at noon; evening at 7 p.m. Reading of papers and discussion continued.
Royal, Burlington-house, W., 4½ p.m.
Linnean, Burlington-house, W., 8 p.m. 1. Mr. F. P. Pascoe, "New Genera and Species of African Curculionidæ." 2. Mr. E. F. Im. Thurm, "Notes on the Plants observed during the Roraima Expedition." 3. Mr. C. E. Broome, "Fungi from Queensland." (Part III.)
Chemical, Burlington-house, W., 8 p.m. Ballot for the election of Fellows.
Society for the Encouragement of Fine Arts, 9, Conduit-street, W., 8 p.m. Mr. E. P. Loftus Brock, "Old Engravings of the Italian School."
Parkes' Museum of Hygiene, 74A, Margaret-street, W., 8 p.m. The Rev. F. Lawrence, "Eremacausis: Sanitary Burials."
Royal Institution, Albemarle-street, W., 3 p.m. Prof. Dewar, "Electro Chemistry." (Lecture III.)
Historical, 11, Chandos-street, W. 8 p.m.
College of Physicians, Pall-mall East, S.W., 5 p.m. (Lumleian Lectures.) Dr. W. H. Stone, "The Electrical Conditions of the Human Body." (Lecture III.)
Numismatic, 4, St. Martin's-place, W.C., 7 p.m.
Cymmrodorion Society, 27, Chancery-lane, W.C., 8 p.m. Mr. Egerton G. B. Phillimore, "The Welsh Historical Triads."

Friday, April 16...Naval Architects (at the House of the Society of Arts). Annual Meeting. Morning at noon; evening at 7 p.m. Reading of papers and discussion continued.
United Service Institute, Whitehall-yard, S.W., 3 p.m. Major E. T. H. Hutton, "Mounted Infantry: (1.) An adjunct. (2.) An auxiliary to Cavalry. (3.) The Volunteer Force in its relation to Mounted Infantry. (4.) Remounts for an improvised Mounted Force."
Royal Institution, Albemarle-street, W., 8 p.m Weekly Meeting, 9 p.m. Prof. Sir Henry E Roscoe, "Recent Progress in the Coal Tar Industries."
Philological, University College, W.C., 8 p.m. Dr. C. A. M. Fennell, "Extracts from the Stanford Dictionary of Imported Foreign Words and Phrases."

Saturday, April 17...Naval Architects (at the House of the Society of Arts), noon. Annual Meeting. Reading of papers and discussion continued.
Botanic, Inner Circle, Regent's-park, N.W., 3¾ p.m.
Royal Institution, Albemarle-street, W., 8 p.m. Professor Oliver Lodge, "Fuel and Smoke." (Lecture II.)
Geologists' Association, 2½ p.m. Visit to the Museum of the Royal College of Surgeons, Lincoln's-inn-fields. Demonstration on *Pterosauria*, &c., by Prof. Charles Stewart.

Journal of the Society of Arts.

No. 1,743. Vol. XXXIV.

FRIDAY, APRIL 16, 1886.

All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

NOTICES.

ELECTRIC LIGHTING ACT (1882) AMENDMENT (No. 3) BILL.

The following petition was presented to the House of Lords on Thursday, 15th April, by the Duke of Abercorn, C.B., Vice-President of the Society:—

To the Right Honourable the Lords Spiritual and Temporal in Parliament Assembled.

The Humble Petition of the Society for the Encouragement of Arts, Manufactures, and Commerce, incorporated by Royal Charter,

Sheweth:—

1. A Bill is now pending in your Right Honourable House, under the above short title, whereby it is proposed to amend the 27th Section of the Electric Lighting Act of 1882, by extending the term for compulsory purchase by local authorities from the maximum of twenty-one years therein given to thirty years; or, with the consent of the local authority, to forty-two years.

2. The Act of 1882 has entirely stopped the development of electric lighting by distribution from a central station to consumers in private houses and shops, and has done so by reason of the oppressive conditions set forth in the said 27th Section, conditions which have deterred capitalists from embarking in undertakings which, if successful, will be compulsorily taken from them upon terms of payment such as must of necessity return to them but a small portion of the capital embarked.

3 The Electric Lighting Amendment Bill (No. 3) does not remedy these conditions, but simply defers the date of compulsory purchase.

4. Your Petitioners are convinced that it will be impossible to raise capital under the new conditions contained in the Electric Lighting Act (1882) Amendment (No. 3) Bill, as it has been proved to be under the original Act itself.

5. An undertaking for electric lighting distribution must of necessity be one of gradual development, needing a gradual calling up of capital, through a period of years as the work developed, but as each year that elapsed would leave a diminished period of enjoyment, it would be impossible to obtain the further instalments of capital needed for such development. Any amendment, therefore, of the Act of 1882, which merely extends the time of purchase, but does not alter the oppressive conditions on which that purchase is to be carried out, will not be sufficient to attract capital to the development of this mode of lighting, a mode that possesses so many advantages, and which, in the opinion of your Petitioners, ought to have a fair trial.

6. Your Petitioners humbly submit that any such amendment as that proposed by No. 3 Bill, as also any other provisions short of the repeal of the Electric Lighting Act of 1882, will be wholly illusory; and that in order to attract capital by dealing fairly with the undertakers, and at the same time to give due protection to the public, an Act should be passed containing such provisions as those set forth in the Electric Lighting Act (1882) Amendment (No. 1) Bill already referred before your Right Honourable House.

Your Petitioners therefore humbly pray your Lordships that the said Electric Lighting Act (1882) Amendment (No. 3) Bill may not be allowed to pass into law, and that the Petition may be referred to the Committee of your Right Honourable House, to whom the Bill has been referred, or that such other relief may be given to your Petitioners in the premises as your Lordships shall deem meet.

And your Petitioners will ever pray, &c.

Sealed with the Seal of the Society
for the Encouragement of Arts,
Manufactures, and Commerce,
this 13th day of April, 1886,
in the presence of

L.S.

(Signed)

F. A. Abel,
Chairman of the Council.

H. Trueman Wood,
Secretary to the Society.

CANTOR LECTURES.

The second lecture of the fifth course on "The Arts of Tapestry Making and Embroidery," was given by Mr. ALAN COLE, on Monday evening, 12th inst. The subject of the lecture was tapestry making. After explaining how the term "tapestry" had been used in two senses, the one, having reference to decorated hangings generally, the other to a special process, the lecturer described the process in detail. He then showed diagrams of early specimens made, during Græco-Egyptian times, by that process. A considerable series of diagrams was devoted to illustrate the predominance, during the period from the 4th to the 13th centuries, in woven and embroidered textiles, of a scheme of pattern (composed of circular band enclosing birds and beasts). The earliest known tapestry-made hanging was wrought with such a pattern. It was a long and narrow hanging, and in this respect corresponded with the long and narrow embroidery of the 11th century, known as the "Bayeux tapestry." It came from the church of Saint Gereon, at Cologne, and parts of it were now preserved in various museums. The fashion of long and narrow bands with patterns of figure designs illustrative of religious, chivalric, and domestic episodes, survived into the fifteenth century. But towards the middle of the fourteenth, a change in size and shape of hangings (tapestry made) had taken place. The lecturer alluded to the principal centres of tapestry-making as they had existed, and showing how change in character of design and treatment from the time of Raffaelle had led to the attempted realisation of pure painting effects in tapestries, like those of Gobelins. He concluded by displaying diagrams of one of the famous Rheims tapestries (early 16th century) of the siege of Soissons, and two of the set of "Petrarch's Triumph" tapestries, specimens of which are at South Kensington Museum and Hampton Court Palace.

The lectures will be printed in the *Journal* during the summer recess.

WESTGARTH ESSAYS.

The three essays by W. Woodward, H. H. Bridgman, and J. Corbett, to which the prizes offered by Mr. William Westgarth were awarded by the Society of Arts in 1885, are now published under the title of "Essays on the Street Re-alignment, Re-construction, and Sanitation of Central London, and on the Re-housing of the Poorer Classes." The volume is published by George Bell and Sons at 15s., but copies can be obtained by members of the Society of Arts for 10s. each, on application to the Secretary.

Proceedings of the Society.

APPLIED CHEMISTRY & PHYSICS SECTION.

Thursday, April 8, 1886; Sir FREDERICK ABEL, C.B., F.R.S., D.C.L., Chairman of Council, in the chair.

The paper read was—

ASBESTOS AND ITS APPLICATIONS.

By JAMES BOYD.

"Asbestos" is derived from a Greek word meaning unconsumable. It is found in the serpentine formation, and seems pretty generally diffused over the surface of the globe. I have had samples of it submitted to me from Cornwall and Aberdeenshire, as also from Portugal, Spain, Savoy in France, the island of Corsica — which I explored in search of it—Switzerland, Germany, Greece, Turkey, and Norway; and recently, in reading Victor Hugo's "Outlaw of Iceland," I noticed the author, in describing the mineral wealth of the island, states "asbestos at Sund Moër." I have also seen samples from the Ural Mountains, from Japan, Australia, South Africa, and South America, but none of these are of any commercial value.

Asbestos, as at present used for manufacturing purposes, is obtained either from Italy or Canada. The first named country is that from which it was first received for manufacturing purposes in this country, and being the one with which I am most intimately acquainted, I propose to give you a brief outline of the different varieties there found, where discovered, in what formation, and the mode of extraction.

Of Italian asbestos there are three distinct varieties, viz., the grey, which has a long strong fibre, and is saponaceous to the touch; the flossy, which has a smooth, silky appearance, but is dry to the touch; and asbestos powder, which, while possessing all the heat-resisting properties of the preceding, crumbles into powder when crushed. Samples of all the three varieties are to be seen on the table.

The grey fibre is found principally in two Alpine valleys, viz., the Valtellina and the Valley of Aosta. To reach the former we start from Milan or Como, sail up Lake Como to Colico, there take the railway recently opened, which runs nearly parallel with the River Ada along a valley bounded on either side by high mountains to Sondrio, the chief town of the province, where we stay overnight in a very good hotel, or we can take a one-horse "char-a-banc," and go on to Chiesa in Val Malenco, where there is also a good hotel. Chiesa stands 3,400 feet above the sea level, and forms a convenient centre for visiting the asbestos mines, in which the valley is rich. At Chiesa carriage roads and bridle paths cease, and anyone desirous of visiting the mines must trust to his feet. Leaving Chiesa, and going nearly due east, we arrive in half an hour at Lanzada, a straggling village, and another two hours' walk, or rather scramble over a road principally composed of loose boulders, brings us to a point where the valley seems quite shut in, whilst to our right the torrent comes foaming through a narrow split in the rock, and high above us, but further to our right, we see the high tableland of Acqua Nera, the face of which seems scored with grey streaks which, on a closer inspection, prove to be workings for asbestos.

Going a few steps ahead, we discover to our left a narrow split in the mountain, and up this, by short zigzags, we make an ascent of about 600 feet, and then along a rising path amongst stunted pines we find the first asbestos mine. Here in the centre of a valley, about 5,500 feet above the level of the sea, we find a serpentine rock about 500 feet in length by about 100 feet broad and as many high.

The asbestos was first discovered near the top of this rock, and on being worked, followed a nearly horizontal direction through it. Before, however, the rock was pierced from side to side, it changed to a nearly vertical formation, and went down into the rock almost like a corkscrew, forming a rough circle of about 35 feet diameter. This was worked from above for a certain distance, and then a gallery was driven to tap it underneath, and this process has been twice repeated, until at present we find this part of the rock internally a cavity of about 50 feet diameter by 100 feet high, with the daylight showing from the crevices above.

The asbestos still continues downwards, but a long and rather expensive tunnel will require to be made before it can be further worked. Turning to our right from this point, and crossing a slight elevation, we find ourselves looking down into Val Brutta, which lies 600 feet below, with a glacier-fed torrent foaming in its midst. We have hardly commenced the descent into this valley, when we come on a large excavation in the face of the rock, perhaps 100 feet broad by 120 high, cut in every direction by thin seams of asbestos, which seem to start as from a centre and spread out in every direction, and these again are traversed by thin seams both horizontally and diagonally. Entering into the rock, these seams generally converge to a centre, where the various thin seams unite themselves, and here a pocket of a ton or a ton and a-half of asbestos may be found, and then all appearance of its presence ceases. Continuing to work inwards, the seams generally re-appear and spread themselves out as before. From the fact that there is no regular seam, but that it is mixed all through the rock as before described, there is no course save to blast the rock to pieces by dynamite, and very many tons of rock have to be dislodged before a ton of asbestos is got. A good discharge for the *debris* is, therefore, an important element in deciding on the opening of a working, and in the mine in question the pieces of rock go thundering down at least 250 feet, and many find their way into, and some leap across, the torrent.

Near this, and on a slightly higher level, was found a seam of asbestos, about 6 inches deep by 5 inches broad, but of such exceeding fineness, that it was judged profitable to follow it up, and to obtain it, make a tunnel about 6 feet square. A sample is on the table.

Still lower down, and near the bottom of the valley, various seams of fine fibre were discovered, and these, on being worked, were found to follow a semi-circular direction, entering a good way into the mountain side, and, finally changing course, came again to the outside, leaving a large isolated rock in the centre. In 1881, this working produced so little that I had given orders to abandon it, but before this was done I paid it a visit, and ordered a pretty heavy bore to be made with a corresponding charge of dynamite, the result being that, when the charge was fired, the piece of asbestos in the case behind was thrown out with other pieces, and I need hardly say the mine was not then abandoned, nor is it yet.

This is the finest piece of asbestos I have ever seen, whether as regards strength or fineness of fibre. Asbestos is found all over the rocks which form the north side of this valley, and are worked in many points; but the workings to which reference has been made may be regarded as types of the whole.

Reference has also already been made to Acqua Nera, which is 6,500 feet above sea-level, and its whole western face is composed of rock which is rich in asbestos, but here the seams follow a nearly vertical direction. In many instances it has been discovered in such positions that the preliminary operations for working have been carried out by men let down from above by ropes, who, in this position, have bored the first holes for forming a working platform. I can state from personal experience that it is not very comfortable nor reassuring to look 300 feet below you, and to feel that there is only a hemp rope between your remaining suspended or going down below.

Leaving Val Brutta and going nearly due north, in about two hours we enter the valley of Scierscien. This is a narrow valley with high rocks on either side, and in its centre a torrent which descends from the Pitz Bernina glacier.

The rocks are about 200 feet high, and to the very top present the appearance of having been ground smooth either by the action of water or glacier, and in them asbestos is found almost everywhere. In one spot, 6,500 feet above the sea-level, a very large number of seams of it were found near the base of one of these rocks, and on being worked, formed an almost perfect circle. In the centre the rock was quite friable and soft, and the asbestos of poor quality, whilst at the circumference the rock was very hard and the asbestos of fine quality.

In this district asbestos is found of fine quality up to ten thousand feet above sea-level, and it is occasionally worked at this elevation; but in some years these seams remain buried in snow. Keeping up this valley, in about twenty minutes we arrive at the foot of the immense glacier which descends from the Pitz Bernina, and here we turn to the left, and, making a long and fatiguing ascent over stone boulders and snow, we reach the Pass of Entova, and descending in a nearly due easterly direction, we come to the asbestos mines in the valley of Entova, 7,000 feet above sea-level, but which call for no special notice. There are also numerous workings in the mountains called Sasso Nero (black rock), at an elevation of 8,000 feet. In passing, I would point out that anyone following this itinerary, and willing to find himself on the top of the Monte Motta, about 8,000 feet high, on a clear morning, can enjoy a view probably unequalled in the Alps. Beginning at the south-east, the eye can trace an unbroken line of glacier from the Pizzo Scalino north to the Pitz Bernina, then west to the Muretto, and then south, and terminating in the Monte della Disgrazia, 12,000 feet high. At the base of Monte Motta, in a dense pine wood, is the beautiful little Lake Palu, which will repay a visit. If, instead of going eastward from Chiesa, we turn west, we begin a rapid ascent, which, in three hours, brings us into the valley of Guimellino, in which are found many asbestos workings at about 7,000 feet above sea-level; and going northwards, over the Monte Lagazzolo and Monte Girosso, many other workings are found all about the same level. As the result of long observation, both on my own part and on that of the Company's Italian *employés*, the following conclusions have been arrived at, viz.:—.

1. That asbestos of good quality is only to be found in the serpentine formation. A fine seam of asbestos was found four years ago in a quartz formation which seemed to upset this conclusion, but it proved just as we suspected, that the quartz was only superficial, and before six feet of rock had been blasted away the serpentine began to crop through. A piece of this asbestos with rock attached is on the table.

2. That if asbestos be found on the face of a rock exposed either to the south or west the product is generally fairly abundant and of good quality. If exposed to the east, there is fine quality but very small quantity, whilst if exposed to the north, the quantity is plentiful but dry and hard, and on entering into the rock all traces of it are lost.

When asbestos is first found in any new place, generally the only superficial indication is that the cracks in the rocks are filled with a white powdery substance. When the surface is broken up, this usually changes into a leathery-looking substance, and entering still further, the true asbestos fibre may be found, but, unfortunately, is not always found. It has been my fortune, on one or two occasions, to discover in time a process which

I believe in America is called "salting." In the case of asbestos, the "salting" consisted in driving in fine asbestos fibre into the cracks of the rock, and trying to make it look like real formation. In one instance which came under my notice, two hundred pounds were paid for the right of extracting asbestos from a rock so treated; the result need not be described.

As to the formation of asbestos I have heard many theories advanced, but I have to confess that I have none to offer.

Having dwelt at such length on the Valtellina mines, I feel constrained more briefly to notice those of the Val d'Aosta. Starting from Turin, we take the railway to Jvrea, from whence in a short time we shall be able to continue our journey by rail to St. Vincent, in Val d'Aosta, a place greatly resorted to in summer for its mineral waters. Asbestos is found over great part of the Val d'Aosta, but the district in which it is found of good quality and in workable quantity lies between the valley of Challand and Val Tournanche, which leads up to the Matterhorn. Here asbestos is found at a much lower elevation than in Valtellina, seldom exceeding 6,000 feet, and the mines are either in pine or chestnut woods, or amongst meadows. The workings are either exposed to the south or south-west, and the formation generally is what I have described in the Valtellina.

The following analysis, by Professor Barff, may be regarded as typical of Italian asbestos fibre, whether of the Valtellina or Valley of Aosta:—

ITALIAN ASBESTOS.

Analysis by Professor F. S. Barff, M.A.

A sample of Italian asbestos fibre, delivered to me by the United Asbestos Company for analysis, contains:—

	Per cent.
Lime and magnesia	37·84
Silica	41·69
Oxide of iron..	3·01
Potash	0·85
Soda	1·41
Alumina	2·57
Moisture evaporated at 100° C. ..	3·04
Loss on heating to white heat, water of hydration, and organic matter	9·56
	99·97
Loss	·03
	100·00

This asbestos contains nothing injurious to metal with which it comes in contact when used in connection with machinery, and the special character of Italian asbestos renders it vastly superior to that found in Canada.

(Signed) FREDK. S. BARFF, M.A.,
Christ's Coll, Camb,
Fellow of the Institute of Chemistry of Great Britain and Ireland; late Professor of Chemistry to the Royal Academy of Arts.

I have dwelt thus at length on the grey Italian asbestos because it forms the material for so many different branches of manufacture; and I now pass on to notice the second variety, viz., floss asbestos. Traces of this are found both in the Valtellina and Val d'Aosta, but so far none of serviceable quality has been found in these valleys. It is found and worked in part of the chain of mountains that bound the valley leading from the town of Susa to Turin, and at an elevation of about 8,000 feet above sea-level. It is generally found in thicker seams than the grey fibre, and the seams are generally horizontal, and dip rapidly as you enter into the rock. There is always a very large quantity of short powdery matter found along with it which is of little value, and often the centre of a piece of it contains pieces of quartz; a specimen of this is on the table. On the table are also to be seen various objects which have been found amongst it, and some of which, in my opinion, must, at some time or another, have belonged to the vegetable kingdom. These are not of sufficient importance to call for a lengthy notice, but an analysis gives results not widely different from those of Professor Barff with grey fibre.

Of this floss fibre there are many varieties, such as mountain cork, mountain leather, &c., but these, whilst curious to look at, have not at present any commercial value.

Asbestos Powder.—This is found in the same range of mountains as the floss fibre, but at a much lower elevation, viz., about 5,000 feet above sea-level. It was first brought to light by a large landslip, which exposed to view a seam of it about three feet broad by one thick, which entered into the base of a hill. When first noticed it was of a pasty consistency, but on exposure to the air crumbled into powder. A quantity of it was excavated and sent to England, as it happened just at the time when an inventor was in search of such a material, and the result will be referred to further on.

With the formation and working of Canadian asbestos I have no practical acquaintance, and the following observations are based on data kindly furnished by Mr. Irwin, of the Anglo-Canadian Asbestos Company, of Cannon-street.

In Canada, asbestos is mined only in the province of Quebec, as although in the provinces of Ontario and Nova Scotia traces or indications have been found, these have never been of such a kind as to warrant any attempts being made to work it.

In the province of Quebec the workable deposits are found entirely in what are known as the eastern townships, which are on or in close proximity to the line of the Quebec Central Railway, which runs from Sherborne to Levis, on the south shore of the St. Lawrence river and nearly opposite the City of Quebec. The formation of that part of the province is metamorphic, and the asbestos is found in a belt of serpentine which extends from the township of Broughton on the north-east, to that of Ham on the south-west, and includes the townships of Thetford, Coleraine, Ireland, and Wolfreston.

In the township of Broughton there is a small deposit of asbestos of very long and fine fibre, but the seams are so few and uncertain that it cannot be worked to a profit, whilst on the south-west ends the seams found are so much mixed with foreign substances, such as chrome iron, that they cannot be worked on account of the great cost, and the poor quality of the asbestos. Practically, therefore, it may be stated that the mining of asbestos is confined to the townships of Thetford and Coleraine.

In close proximity to the station of Thetford are the only producing properties, four in number, that are to be found in that township, and the principal amongst them are the property of the Asbestos Packing Company of Boston, who send all the product of their mines to their manufactory at Boston.

In the township of Coleraine there are only three producing properties, two of which are owned by the Anglo-Canadian Company of London. The whole district in which asbestos is thus mined has a radius of about ten English miles.

The asbestos-bearing lode of serpentine varies in width from 10 to 100 feet, and in many parts contains innumerable veins of asbestos varying from an eighth of an inch up to four inches thick, which cross and re-cross each other in every direction and at every angle. Frequently several veins are found parallel to each other, being only separated by thin layers of chrome ore. The outcrop of the veins are generally impure, containing oxide of iron, and instead of being fibrous are like leather, but a few feet in, this disappears, and the veins are of a beautiful greenish white colour. The mining of asbestos is wholly conducted by opencast or quarrying.

One curious feature of Canadian asbestos is, that although fire-resisting, and in no way affected by acids, it is very easily damaged if exposed to rain or water in its crude state; and a few days ago I was shown some, which having got wet, had become hard almost like a piece of wood. The following may be regarded as an average analysis of Canadian asbestos:—

Lime and magnesia	33·20
Silica	40·90
Oxide of iron	5·75
Potash	traces
Soda	·68
Alumina	6·60
Loss on heating to white heat, water of hydration, and organic matter	12·50
Chlorine	·25
	99·88

APPLICATION OF ASBESTOS.

The valuable fire-resisting properties of asbestos has been long known. In the history written by Marco Polo of his travels and adventures in China, in the latter half of the 13th century, we find him mentioning an incombustible cloth which was said to be made from the skin of the salamander, a serpent which could exist in the fire, but which, on examination, he found was made from a fibrous mineral, viz., asbestos, and he goes on to detail its treatment and manufacture.

I have also seen in the Vatican a piece of abestos cloth, which, however, seemed to have some foreign fibre mixed with it, probably in order to facilitate the spinning. Some think this was one of those napkins which are said to have been used by popes and emperors to astonish their guests by throwing it, when soiled, on the fire, which cleansed it from its impurities. This may have been possible with the charcoal fires then in use, but with our coal fires it would probably be further soiled, rather than purified by such treatment. Others there are who assert that these cloths were used by the Greeks in cremating their dead, so as to keep the remains of the body from mixing with the fuel.

Either or both these theories may be correct.

The asbestos from which these cloths were made is generally supposed to have been found at Paphos, in the Island of Cyprus. From the year 1850, various attempts were made by Italians to utilise the asbestos, so plentiful in their mountains, but these were chiefly directed to manufacturing it into cloth, and chief amongst those who did this was the Chevalier Aldini.

Amongst those who were the means of bringing asbestos within the pale of mechanical application was the Italian priest Guiseppe della Coronna, a native of Florence, whom I had the pleasure of knowing. After many experiments he had, about 1870, succeeded in making asbestos into millboard and paper of very good quality.

About the same time some Americans had succeeded in manufacturing the Italian asbestos into packings for piston glands; and in 1872, a company was formed at Glasgow, called the Patent Asbestos Manufacture Company Limited, for the purpose of making piston packings according to the American invention. This company also made a contract with the Italian millboard manufacturer for his make of millboard, and to it belongs the merit of having first offered asbestos in a form suitable for the engineer.

This company adopted as its trade mark the salamander in a fierce fire, but whether in reference to Marco Polo or not, I am not aware. A sample of the packing of 1873 is on the table, and, as may be seen, consisted of a core of asbestos fibre consolidated by special machinery, and braided over with cotton to hold it together. That this was a crude and imperfect way of applying asbestos is apparent, still some wonderfully good results were obtained from its use, as, for instance, in the Anchor Line s.s. *Anglia*, the engineer of which stated that "the packing had proved highly satisfactory, having been in use while the vessel steamed 24,000 miles." The rod was in beautiful condition, and the gland was only screwed up a turn at the end of each voyage.

Prior to 1880, I had been for a number of years interested in and connected with this company, and in that year, by its fusion with the asbestos business of Furse Brothers and Co., of Rome, and the Italo-English Pure Asbestos Company, was formed the United Asbestos Company, Limited, with which I am still connected.

In further dealing with the subject, it is my intention to notice the various developments of asbestos for packing and jointing purposes, and thereafter the other uses to which the material has been applied.

Packing.—The rapidly increasing favour with which high pressure steam is regarded by engineers, has necessitated the use of packing fitted to resist the higher temperatures and pressures, and as the heat-resisting properties of asbestos indicate it as a suitable material, manufacturers of asbestos goods were stimulated to devise improved methods of manufacture so as to meet the altered conditions of things, and the forms in which asbestos packings are now to be found are numerous.

Samples of the different varieties are to be seen on the table, and I need do little more than enumerate them.

First of all, we have yarn composed of a single thread, or it may be of three, six, or nine threads softly twisted together, and which is largely used for packing small glands, taps, &c., and is found of great use by engineers.

Then we have the ordinary braided packings composed of parallel strands of thread forming a core, over which asbestos threads are braided or plaited and form the rubbing surface.

This packing can also be had of a square instead of a round section. These are the packings in everyday use, and for engines using steam of moderate pressure give wonderfully good results.

When I have heard people who use it tell how long the same packing had been in use in a valve or gland, I have often felt tempted to say it lasted too long.

To meet the views and wishes of engineers, soapstone or plumbago is also frequently incorporated with this packing, and it is said to give very good results. For engines using steam of a higher pressure, but where a moderate price is an indispensable condition to its use, this packing is greatly improved by being braided or plaited all through instead of having a core composed of parallel threads, and this is the class of packing in use in the Royal Navy, as also in many merchant steamers.

The ideas of engineers as to what forms a good make of packing vary very greatly, some desiring to have it made almost as hard as iron, whilst others desire to have it so soft that it can be pressed into any shape; and, to meet the views of the latter, there is offered by the company with which I am connected a woven packing composed of parallel threads bound together in a particular manner, and which can be pressed into any form. This is largely used by railway companies, and I have known many instances in which this packing, after six months of continuous use, still remained tight and serviceable.

Asbestos manufacturers in pushing their sales soon discovered that many engineers had a deeply rooted preference for packings of the well-known Tuck's form, and to meet this desire, asbestos has been manufactured into cloth, and made up both into round and square packing, either with or without rubber, core, or backing, and has given very good results. The square form is preferred by marine engineers, and the engineer of a steamer belonging to an important company recently made the following report respecting it:—"We packed the H.P. slide and expansion rods with it in London, these being the two we had the most trouble with; we made the whole voyage out and home from Calcutta without putting any more packing in, and it was quite steam-tight after running over 16,000 miles. When using Tuck's packing, we had to repack about four times a voyage, and sometimes stop at sea to repack; so, although the first cost is dearer, I think it will be economy in the long run to use it."

The round form of this has been found of great value by engineers in cases where wet steam has to be dealt with, and I am aware of an instance in which it was used for packing the piston-rod of a Condie's steam-hammer, in which any other kind of packing lasted only a few days, whilst this lasted over three months, when it still remained in serviceable condition.

Finding that many engineers had a great liking for metallic packings, about a year ago I began to make experiments, with a view to determine in what way I could best meet their views, and the result may be seen on the table in the shape of a packing of which each thread has a core of very fine brass or bronze wire. This metallic yarn can be either braided up into a square or round packing. It can also be woven into cloth, and made up into round or square packing of the forms already described as similar to Tuck's packing, and for other purposes which will be noticed under their proper headings.

Having thus briefly glanced at the applications of asbestos as a packing, I propose to notice its applications as a jointing material. First in order it comes to us in the shape of millboard, which, as already stated, was originated by the Priest Coronna. It is not necessary I should say much on this point, as many of you are, doubtless, familiar with it, and for those who are not, samples are to be seen. Much of this is sold in the sheet to buyers who cut it up into joints as they require it; but there are other consumers, such as railway companies, to whom these joints are supplied, cut to the various forms in which it is required, and I believe I am correct in saying that in no single instance have these given way or blown out of the joint.

To show the variety of forms in which these are used, samples are exhibited of the various forms of joints used by the principal railway companies, and I may further mention that these millboard joints are kept in stock as standard washers, the same as in india-rubber.

Millboard not being, however, sufficiently elastic for some purposes, and not well adapted for joints with wet steam, some buyers desired to have something more nearly resembling rubber jointing, but of greater resistance to heat. Asbestos has been woven into cloth, and this cloth proofed on both sides with rubber, and several thicknesses of cloth can be stuck together according to the thickness desired. This forms an admirable joint for water or wet steam, or where the surfaces are not quite even, and if rubbed with soapstone or plumbago before being applied, does not adhere to the metal, and may be used several times over. This cloth proofed with rubber is made up into a great variety of tapes for ordinary joints, or thick for manhole joints of steam boilers, and is also made into joints of all forms, whether square, rectangular, circular, or oval. The metallic cloth already referred to can also be made up into all the classes of goods just mentioned as being made from pure asbestos cloth. Yet one application of asbestos as a jointing material remains to be noticed, viz., as a putty. I have seen this remain sound after being for two years continuously exposed to the action of fire in the flue of a steam boiler carrying 50 lbs. pressure.

SUNDRY APPLICATIONS OF ASBESTOS IN THE STATE OF MILLBOARD CLOTH OR FIBRE.

1st. Millboard as lining for fireproof cases or deed boxes. With a view to provide a receptacle for papers or other articles of value which will be moderate in cost and at the same time portable, deed boxes with a lining of asbestos millboard have been introduced, and I trust that, as their value is better known, they will come into general use.

About two years ago, some gentlemen who desired to see these boxes put to a practical test, visited the company's works at Harefield. Two rails were supported on brick at a height of 18 inches from the ground, and underneath them a strong fire of wood shavings and chips was made, and when this had well burnt up, one of the deed boxes filled with papers was pushed along the rails to the centre of the fire, where it was completely enveloped in the flames, and there it remained for twenty minutes. On being withdrawn it unlocked easily, and the papers were found in perfect preservation, being neither charred nor discoloured.

On seeing this result, one of the gentlemen present asked if the boxes could not be used for transporting gunpowder or other explosive substances. A quarter of a pound of gunpowder was put in a small bag, and placed inside a fresh box, which was pushed along the rails into the centre of the fire, which had fresh fuel added. Those present withdrew to a respectful distance, evidently not having absolute faith in the heat-resisting properties of asbestos, and after it had been exposed for twenty minutes, the question arose how is it to be got off the fire. By means of a long iron rod with a hook, I performed this operation, and the box was opened and the powder found intact. The same gentleman then asked, "Why have the powder in a bag? Let it be laid on the bottom of the box loose." This was done, the fire ordeal repeated, with the same result, the powder did not go off.

Asbestos tubing. — To provide electrical engineers with a non-conducting covering for their wires, which is both fireproof and waterproof, and thus guards against the risks of fire, and preserves the perfect insulation of the wire, asbestos millboard is made into tubes of all diameters, and are fitted with sockets for joining the lengths, and with elbows for turning corners. They can also be made internally in two or more divisions. Samples of these are on the table, and they are found to give excellent results in practice.

Asbestos millboard is made into gas shades and also into fire-blowers, and for both purposes its fire-resisting properties have been found of great value.

Asbestos paper has also been printed in imitation of wall-paper, and should be valuable for papering internal wooden divisions in houses or offices.

Asbestos is also made into a felt suitable for placing under carpets or oilcloth.

2nd. *Asbestos Cloth.*—This has been very largely used by beetroot sugar refiners in France, Germany and Austria for filtering purposes, it being found that filter bags made of this material were much better fitted for this purpose than those of any other, as they lasted very much longer, retained the heat, and were easily cleansed and kept sweet. Asbestos cloth has also been largely used for the filtration both of acids and water, and with the best results. One of the uses for which the fire-resisting properties of asbestos indicated that it was specially suitable in the form of cloth was as a fireproof curtain for theatres.

Some years ago, when the disaster at the Ring Strasse Theatre in Vienna—in which so many fell victims to the flames—had drawn attention to the great danger arising from the want of some certain and rapidly applicable means of separating the stage from the body of the theatre, the Roman Minister of Public Security issued an order that every theatre should be fitted with a fireproof curtain, capable of entirely isolating the stage from the theatre, and he indicated an asbestos cloth curtain as one that would meet the case.

Shortly afterwards, my company supplied from their Turin works fireproof asbestos curtains for all the principal Roman theatres, and although I am not aware of any of these having been put to a practical test, I have no doubt of their ability to resist the action of fire should the case ever arise.

The company has also supplied asbestos cloth fireproof curtains for several English theatres, but I am not aware that these have ever been practically tested.

In Germany, a strong coarse make of this cloth is largely used for protecting the clothes of men employed in the manufacture of iron and of acids, and of fire-proof clothes for firemen. I have often wondered whether the fire-resisting properties of asbestos could not be utilised in the form of bags for the carriage of gunpowder, especially in time of war, as I can conceive many cases in which it would prove itself to be of much value.

The most recent application of asbestos in this form, with which I is acquainted, is at the Midland Grand Hotel, St. Pancras. There is a balcony entered from the reading room, and in summer this balcony is a favourite resort of smokers. To protect its frequenters from the sun, this balcony had a canvas awning, which, through carelessness, has, on more than one occasion, been set on fire, thus endangering the safety of the building. My company has recently received instructions to supply an awning of asbestos cloth for this balcony, which will soon be put into position. I believe this step has been taken by the railway company so as to secure their premises against the danger of fire, but have no doubt that in hot weather the frequenters of this balcony will discover that, owing to the valuable non-conducting properties of asbestos, they will enjoy a much cooler and pleasanter smoke under it than under a common canvas awning.

Applications of Floss Fibre.

This kind of fibre is principally used in the manufacture of gas-stoves, but as I have been informed that a paper on this subject has already been read before this Society, I do not consider it desirable to take up your time with any attempt at describing the various forms of apparatus in which it is used. Samples of this material in its natural state are to be seen on the table. As already stated, in mining this fibre a very large proportion of short powdery material is found, and I now propose to state briefly the uses to which this can be applied.

First amongst these is its applications for covering steam boilers and pipes with a view to prevent the radiation of heat, and thus ensure economy in fuel, and also increase the evaporative power of the boiler. This material thus applied is made almost of the consistency of mortar, and certain chemical ingredients are added, which, whilst not injurious tothe metal, cause the asbestos to adhere firmly to the plates, and when dry it becomes quite hard, and can be walked over without injuring it. With a boiler carrying, say, eighty pounds steam pressure the application of from 1½ to 2 inches in thickness of this composition so well retains the heat in the boiler, that a thermometer with its bulb held close to the outer surface of the covering will not indicate more than from 80° to 85° Fahrenheit.

I was recently asked to see a small cross-channel steamer, the owners of which desired to have the boiler covered with asbestos composition. The engineer's berth was in close proximity to the boiler, and partly over one side of it, and he had a mournful tale to tell of the extremely high temperature he had often to bear even during winter. He had heard of the non-conducting properties of asbestos, and seemed almost desirous of having the boiler buried in it; in fact there was no satisfying him with the thickness of the composition. I advised him to have it 1¾ inches thick, and said to him, laughingly, "Take care not to put it on too thick, otherwise you may make your berth too cold." It was put on 2 inches thick, and after it had been two months in use, I made inquiry as to the result, and was amused to hear that the berth was really felt too cold, but that the tonnage of coal consumed each voyage had greatly decreased.

Some years ago, I was residing in Genoa, and was a member of a committee for procuring a new floating chapel for the use of British seamen frequenting that port. The old chapel was built on the deck of a hulk, but the extremely high summer temperature rendered repairs both frequent and costly. For this reason, the committee were desirous of having the new chapel built of iron, but were deterred from this by the fear that its roof and sides, when exposed to the summer sun, would get so hot, that the temperature inside would be quite unbearable. Being fully cognisant of the value of asbestos in such a case, I proposed to fill up the space between the outer skin and the inner boarding with this kind of asbestos, ground to a rough powder, and after some difficulty I induced the committee to make the experiment. When the carpenters began to put in the lining, the space of about 1¼ inches was tightly rammed full of this powder, both up the side and end walls, and across the ceiling, and as the chapel was built at the beginning of the summer, we had not long to wait to learn the result.

A careful series of observations of the temperature inside and outside of the chapel was continued over several months. I regret that having mislaid these, I am unable to give the figures, but the general result was that whilst outside the temperature was about 100°, inside, if the doors and windows were kept shut the temperature did not exceed 70°, and was deliciously cool. On several occasions I have heard captains who had come on board ask how we were able to keep the chapel so cool.

I have often wished I could get the owners or managers of some our floating palaces which navigate the Suez Canal or Red Sea on board this chapel, as I feel sure that the deck cabins of these steamers could, by such an application, be made much more comfortable for the passengers.

I have noticed these two cases as showing that asbestos is equally valuable either for retaining or excluding heat. The only other application I will refer to in connection with this material is one most of you are familiar with, viz., the blocks or balls for gas fires.

APPLICATION OF ASBESTOS POWDER.

The name of the company with which I am connected has been so much mixed up with fireproof paint, and the public experiments made with it, both in England and on the Continent, and also Australia, that I feel it would be mere affectation trying to speak of the paint apart from the company.

Reference has already been made in this paper to a sample of asbestos powder having been sent to England at a time when an inventor was in search of such a material, and the result was publicly exhibited at the Crystal Palace in January, 1882, in the presence of the Lord Mayor and other distinguished personages.

The public experiments given have, I venture to think, demonstrated clearly that this paint will preserve woodwork from being consumed by the action of fire for a lengthened period, and that, although by continued exposure to a strong fire the wood may become carbonised underneath the paint, it cannot become an agent for communicating the flame to surrounding objects, and thus it serves to retard the progress of the flames until the firemen can get set to work to extinguish them.

This paint was extensively used at the various exhibitions held at South Kensington, and, in May, 1884, was put to something like a practical test, as an exhibitor's stall took fire, and was burnt to ashes, but the fireproof paint with which the wall was painted prevented the fire from spreading, and it was extinguished, by the aid of a portable engine, in a few minutes. This paint had, however, some defects; amongst others, that it could not very well be applied to smooth worked timber, and, when exposed to the alternate action of a strong sun and heavy rain, it inclined to lose its hold of the timber, and did not present such a smooth, finished appearance as to fit it for house-painting.

After long continued experiments, Mr. Mountford, the manager of the company's paint department, has now succeeded in manufacturing a paint which resists the action both of fire and water, and is thus fitted for either indoor or outdoor application. It can also be made in any colour, and presents a smooth, finished surface, fit for use either in dwelling-houses, offices, or other buildings. It can also be applied over old oil-paint, which is an important point, as great outlay is incurred where it is necessary to thoroughly clean off old paint before applying a fresh coat. Samples of the various colours as applied to pieces of timber are to be seen on the table, as also a small quantity of the paint.

To the use of asbestos as a filtering agent reference has already been made, and I crave your indulgence for a moment to draw attention to its application for filtering water.

For the efficient filtration of water the essentials are a sufficiently energetic chemical action for the removal or destruction of deleterious matter in solution, and perfect mechanical straining for the removal of suspended matter.

There are many filters before the public in which asbestos is used in some form or other, such as Maignen's, Lipscombe's, or the Silicated Carbon Filter Company; but the filter known as Judson's being that with which I am best acquainted, I propose briefly to refer to it. The filtering agent employed in this filter gives off minute particles of oxide of iron, to remove which a straining medium is required. Porous blocks, or slabs of carbon, or silicates of various kinds meet this requirement, but, unfortunately, they sooner or later become clogged; and although instructions for cleaning these by brushing or scraping are sent out by the makers, it has been found practically impossible to do this cleansing efficiently, and the block itself becomes a source of impurity.

An obvious remedy would be to remove the block and replace it by a fresh one, but in practice it is found that the fresh one cannot be put in in such a way as to prevent particles passing round the joint. By, however, substituting a layer of carefully cleaned and carded asbestos fibre for this block, perfect mechanical straining is insured, and this can be removed and replaced by the most uninitiated, and this is the system adopted in this filter.

The last application of asbestos, to which reference will be made, is for the purification of foul gas. I was recently asked by a firm in the north of England to supply asbestos yarn spun in such a way as to have good capillary action, and on making inquiry I found it was to be used by Messrs. Adams and Co., of York, for their ventilating and deodorising manholes for sewers, cesspools, &c. In this arrangement there is placed over the opening rising from the sewer a hood of galvanized wire interlaced with this asbestos yarn, and the ends of the yarn dip into a receptacle filled with liquid disinfectant, and as they become saturated form a disinfecting screen, through the meshes of which the gases rise, and in their passage are purified and rendered innocuous.

The system generally adopted hitherto for deodorising sewer gas has been to cause it to rise through charcoal, but the impurities soon clog this up, and simply prevent the passage of the gas, whereas in Messrs. Adams's arrangement the gas rises freely, and is perfectly deodorised.

In speaking of such varied applications of asbestos it may seem strange that I have refrained from touching the much-debated question whether Italian or Canadian is the best. Each have their advocates and their partisans, but I do not consider the present a fitting occasion to deal with this question, and I therefore limit myself to saying that whilst for certain uses the one may be as suitable as the other, it is not so in all cases. As an examination of the samples will show, the Italian is long and strong in its fibre, and is saponaceous to the touch, whilst the Canadian is short, and to the touch is as dry as chalk; and, therefore, it seems to me that the properties of Italian indicate it as better suited for the engineer's use, especially in the form of packing or jointing.

In conclusion, I beg leave to say, that if any of my hearers are desirous of personally making themselves acquainted with the asbestos formation by a visit to the mines, I shall have pleasure in facilitating their doing so, and I shall also be glad to give any further explanations regarding it.

DISCUSSION.

Mr. P. A. **Maignen** said that since lead, copper, and iron pipes were all more or less under a cloud for water purposes, it would be interesting to know if the asbestos tubes which had been described could be made suitable for conveying water; and if it was not a trade secret, he should be glad to know the materials of which the millboard, of which the tubes were made, was composed. Mr. Boyd had said that he had not had much experience of Canadian asbestos; but he (Mr. Maignen) might remark that the fibre was very short, only one inch to one and a half inch long, and so fine that it was considered for a long time impossible to make use of it for weaving. Messrs. John Bell and Sons, however, had produced a machine which had so dealt with this short fibre that it could be woven into cloth. It had been customary in America and elsewhere to mix cotton, or some acid or gluey substance, with the asbestos fibre, but such mixture rendered the cloth produced useless for water filtration. His name had been used, probably because he was the first to use asbestos cloth largely for water filtration, and he hoped before long it would take the place of sand on the scale required for the water supply of London. Many hundreds and thousands of yards in his filters had been used in Egypt with great success during the last campaign, and no doubt to this cause the excellent health of the troops was largely due. He first used asbestos cloth in filters some six years ago. He had previously used canvas or felt, sometimes an inch thick, but the result was that, with soft rain water in which ammonia was present, this felt soon became as rotten as wet blotting paper. Messrs. John Bell and Sons at first feared that asbestos would prove too expensive to use for the filtration of water, and it took them two years before they could manufacture pure asbestos cloth of exactly the right porosity to arrest the fine filtering medium which was employed in his filter to purify water chemically. By some accident a piece of cloth was sent him, some two years ago, which was most beautiful in appearance, made of fibre purchased in America, but after a short time the filters made with this cloth were complained of, the water becoming positively offensive. He soon discovered, by submitting a piece of the cloth to the fire, that it was mixed with cotton. Since then the firm in question guaranteed that all the fibre used in making his cloth was wrought out in this country direct from the raw material. He regretted that Mr. Boyd had thought it right to mention names in relation to filters, and recommended a particular one, as it laid upon him the obligation to make observations on the subject. It was suggested that oxide of iron was given up to the water, and that it was afterwards arrested by asbestos fibre at the bottom of the filter. Now, if the water dissolved the iron, he made bold to say that the asbestos would not remove it; and if the asbestos fibre were put loose at the bottom of the filter, it would, in his opinion, pass through any hole in the stoneware. The use of asbestos for the filtration of sewer gas had been referred to; he could mention another instance in which it was used, not as a strainer, because no gas would pass through wet asbestos cloth, and he thought the value of liquid purifiers was somewhat questionable. In the invention of Mr. Eedes Eachus, of 2, Great Queen-street, asbestos cloth was used as a packing round the bottom of a filter which wedged into a conical manhole, being one of two forming an upcast and downcast shaft. Between these two at the bottom, in the sewer itself, was a flap, which obliged the sewer gas to pass upwards through a charcoal filter, which was protected from damp by the dirt box at the top of the manhole having an overflow into the downcast shaft. In this way localisation, aeration and filtration, were secured. There had been various suggested methods for filtering sewage gas through charcoal, but the difficulty had always been to make a joint between the filtering medium and the manhole or other arrangement; but asbestos cloth had been found perfectly effective for this purpose.

Sir JAMES ALLPORT (Chairman of the United Asbestos Company) said he first became acquainted with this material some eight years ago, when he visited the mines in Italy, inquired into the uses to which it was put, and felt that it was a subject which deserved commercial attention, and to be brought before the public in a more extensive form than had up to that time been done. It had been introduced by an Italian company and a Glasgow company, and he established a third, and these three were now united. He invited those interested in the matter to examine the various specimens which were exhibited, and especially to notice the difference between the Italian and the Canadian asbestos, the former being far superior in every respect, especially in its capability of being woven into cloth. He was aware that cotton had been mixed with asbestos by American manufacturers of asbestos cloth, but it would be found that the cloth on the table was composed of pure fibre, incapable of injury either by fire, water, acid, or oils, and consequently was very valuable for the various purposes which had been described in the paper. When he was in Naples two years ago, he saw in the museum there a piece of cloth, of ancient Roman or Grecian manufacture, which was so identical in appearance with that now made, that very few persons would be able to detect the difference. He had never yet seen anything to equal this material as a non-conductor or heat-resisting substance, and ultimately it must come very largely into use. It had been used both by the War-office and Admiralty, and had proved eminently successful for the purpose for which it was required. Its superiority as a packing had been proved on many occasions, its durability being so remarkable.

Sir J. H. MAXWELL said he had used one of the filters referred to by Mr. Maignen for the last three years, and it gave every satisfaction. At first there was a little difficulty, as usual with anything new, but he soon was able to instruct his servants how to use it, and it had been in use for some time, and, as far as he could see, it purified the water in the most perfect manner.

Mr. WARINGTON SMYTH, F.R.S., said he had met with asbestos in a great number of different localities during the last forty years, though he had not been connected with it commercially in any way. They were much indebted to Mr. Boyd for having, as far as he was aware, for the first time given a clear and distinct account of the connection of this mineral, in its most useful form, with certain classes of rocks, and with certain districts. Thirty or forty years ago very little was known about the use of asbestos, and not much about where it could be found. They were aware that in ancient times it was employed for various purposes, but only on a small scale; and thirty years ago no one could have had any conception of the many uses to which it could be put for the safety, convenience, and comfort of mankind. The public owed a great deal to the various companies and gentlemen who had gone into the matter, and spent much time and money in improving the manufacture. Years ago, in collections of minerals for geologists, there used generally to be specimens of asbestos obtained from the eastern part of the Alps, partly from Switzerland, but in great measure from certain localities in the Tyrol. The impression was that the asbestos offering the best appearance was that found in connection with hornblende or amphibol. This contained, as appeared from the analysis, a larger proportion of alumina, and as he now gathered, the most valuable kinds appeared to be those which contained a large proportion of magnesia, and were found inmately connected with the rock called serpentine. The serpentines in various parts of Europe could scarcely be examined without finding them intersected with fissures which, generally speaking, ran from a quarter of an inch to two or three inches in breadth, and contained asbestos of more or less suitable quality, but the fibre was so short as compared with those now brought forward, as to probably exclude them altogether from practical use. In this country there was a considerable quantity of serpentine, especially in Cornwall, in the Lizard district, also near Liskeard, in the island of Anglesea, and in Scotland. He had long been familiar with varieties of asbestos from these localities. Any one could find specimens on Clicker Tor in the neighbourhood of Liskeard, but they were always so limited in breadth, that the fibre could not pretend to compete with any of these which were brought to such perfection as manufactured products. One application appeared to have escaped the notice of the author, but which, as the result of many experiments which he had had the pleasure of being connected with in company with the Chairman, was destined to save the lives of many miners. It had been found very difficult to get a good joint between the metallic part and the glass part of the miner's safety lamp, and a great many different materials had been tried as washers for filling these joints in such a way that the air should not be able to get through. In many cases the air was contaminated with a certain amount of gaseous material, which would render the whole explosive, and if this got through the joint between the glass and the metal, there was a serious risk of explosion. After various substances had been tried and found unsatisfactory, a great number of experiments—some hundreds—were made with asbestos washers by the Chairman and himself, and at the end of this long series of experiments, they had maintained their condition most admirably, so that their use could be strongly recommended. This was only one of the numerous applications of asbestos, and he could not but feel that this paper, illustrated as it was, by so many interesting specimens must be most valuable to men engaged in mechanical business.

SIR JAMES ALLPORT said he had omitted to point out the various samples of pure asbestos, both Italian and Canadian, which he then proceeded to do. The latter was much shorter in fibre, and presented very much the appearance of what was called "furnace wool" in the iron districts. He had also forgotten to mention that many experiments which had been made at the Crystal Palace, South Kensington, and elsewhere, on asbestos fire resisting paint. There was no doubt that its application for this purpose was one of the most useful to which it could be put.

MR. BOYD said the asbestos tubes were made for the purpose of carrying electric conductors, not for conveying water, and he was not in a position to say whether they could be made suitable for the latter purpose. With reference to the composition of the material, there were obvious reasons why he could not be expected to give the information asked. Those who spent money in perfecting a manufacture desired to preserve their secret as long as possible. When he stated that he had not much experience of Canadian asbestos, he referred to the crude material, not to the manufactured article. He had tried, as far as possible, to keep his company's and personal interests in the background in preparing the paper, and to simply treat asbestos as an industry, without reference to those who had been connected with it. A strong claim had been put forward on behalf of a certain gentleman as having been the first to spin asbestos, but he was in a position to prove that he did it much earlier. With regard to the mixture of asbestos with cotton, he remembered when the company first began to work Canadian fibre, he bought a small parcel of carded fibre; but one morning the foreman came in with a piece of rag in his hand and asked him if that was to be called asbestos. He then discovered that their friends on the other side of the water had been getting cotton or woollen rags and carding them down into fibre along with asbestos. It was needless to say that from that time he bought no more carded American fibre; they procured the raw rock and carded it themselves. He was much pleased with the remarks of Mr. Warington Smyth, and hoped he would go and visit the asbestos mines he had described. He had been in the Tyrol in search of asbestos but had to abandon the search, as he could find nothing to suit him in that direction. The use of the cloth in connection with safety lamps was new to him, but they had for some time been supplying rings of millboard called lamp washers, which were probably used for this purpose. There was yet another application of asbestos which had not been referred to. A considerable quantity of fibre had been supplied to the Royal gun factories, and though he did not know much about it, he fancied it must be for forming an elastic disc—a sort of cushion between two discs—for effectively closing the breech of large guns, to prevent the passage of any gas. Asbestos was a new industry, and would really afford material sufficient for a series of papers.

The CHAIRMAN said this subject was one of such great interest that they were much indebted to Mr. Boyd for the very comprehensive way in which he treated it; and no doubt the information he had brought forward would be novel to many. If time permitted, he could mention several other applications which Mr. Boyd even perhaps was scarcely aware of. He was quite correct in supposing that the asbestos supplied to the Royal Gun Factory was used in connection with breech-loading guns. Amongst the various contrivances which had been devised for effectively closing the breech of a large gun, almost the only one which could be called an approach to a perfect arrangement was one devised by a French artillery officer, M. Dubange, which consisted of a kind of pad of asbestos fibre, attached to the breech-closing arrangement. It was, from its mineral nature, nearly indestructible, and, therefore, lasted without material deterioration for a great length of time, although subjected to the enormous pressures which were now developed in the bores of heavy guns. There were also other military applications of very great interest, though comparatively small in themselves. For instance, in connection with the manufacture of time fuzes, washers of this material were used. They used to employ washers of leather and india-rubber, but it was found that these either became hard in time, or acted on the metal surfaces with which they came in contact, cementing them together instead of keeping them mobile, and it was not until the introduction of asbestos washers, that difficulties in connection with the proper action of these ingenious contrivances for the explosion of shells in a given time after their discharge were removed. Again, in connection with the Whitehead torpedoes and similar other receptacles within which charges of wet gun cotton were enclosed, asbestos was useful in getting over a very great difficulty. They were obliged to solder the vessels containing damp gun cotton, in order to keep them perfectly air-tight, and thus prevent the water from escaping; and in order to do this with anything approaching safety, the space between the gun cotton and the metal surfaces which had to be soldered was filled with damp felt wads or discs. This answered the purpose, but after they had been stored for some time, the effect of the moisture on the felt was to cause it to undergo a kind of decay or fermentation resulting in the formation of gas to such an extent that the vessels were distended and threatened to burst, and sometimes actually did burst with considerable violence. Asbestos millboard was then substituted for the felt, and this got over the difficulty; there was no longer gas evolved, the operation of soldering could be performed with the same safety, and the material remained perfectly unaltered. Mr. Warington Smyth had referred to one most important illustration of the recent use of asbestos in connection with safety lamps. Indestructible wicks were also used in some forms of safety lamps, and several other important applications of this remarkable material on a small scale might be mentioned. He thought the whole world were indebted to those gentlemen who had devoted their energies to the conversion of asbestos fibre, long or short, elastic or brittle, into the various forms which were so useful. Great credit was due to Mr. Boyd, and also to Mr. Bell; and probably the gentleman who had the most difficulties to contend with, enlisted their sympathies most strongly; if he had been able to convert very short and brittle fibre into cloth and other useful materials, he had done great things, although he might not have produced quite so perfect a cloth as was formed from the long fibre. He concluded by proposing a vote of thanks to Mr. Boyd for his interesting paper.

The motion was carried unanimously, and the meeting adjourned.

FOREIGN & COLONIAL SECTION.

Tuesday, April 13, 1886; HYDE CLARKE in the chair.

The CHAIRMAN, in introducing Mr. Simmonds, said it was impossible to open the proceedings of that Section without referring to the great loss sustained in the death of Mr. W. E. Forster. He would not deal with his public qualities in general, which had already been fully dealt with elsewhere, but he was known to all English colonists as the advocate of a united Empire. The Society, and that Section particularly, had been under great obligations to him; he took great interest in the work of that section, and Dr. Mann, the secretary of the section, who was unfortunately absent that evening from a severe cold, was in constant correspondence with him, and last year it was Mr. Forster who arranged with them for the paper on "Federation." He had hoped to have taken the chair on that occasion, but the seeds of his fatal illness had already affected him, and induced him to lessen his public duties. In the present session it was hoped that with restored health he would have been able to preside, but unfortunately this had not been possible. It would have been more pleasing to himself if someone of greater importance had taken the chair on this occasion, but most of their Colonial friends were that evening enjoying the hospitality of the Lord Mayor. Mr. Simmonds would therefore be spared their criticisms, but on the other hand he would lose the tribute which they would no doubt have paid to the value of the paper he was about to read. He had known Mr. Simmonds for very many years, having worked with him more than forty years ago in the school of Robert Montgomery Martin, to whom more than anyone else probably they owed the idea of a united Colonial Empire. In that work of his, "The History of the Colonies," to which Mr. Simmonds was a contributor, he for the first time brought before the public in an effective manner the whole range of our Colonies, and though it had been to a great extent superseded by the very great progress of the Colonies, some of their friends still acknowledged that they owed to Mr. Martin in great degree the idea of considering the Colonies as a whole, which idea had resulted in the acceptance of what he believed was now a settled doctrine, that of federation.

The paper read was—

PROGRESS OF THE BRITISH POSSESSIONS IN THE LAST QUARTER OF A CENTURY.

By P. L. SIMMONDS.

The interval between the Exhibition of 1862 and the present Colonial Exhibition, forming a period of nearly twenty-five years, appeared to me a favourable opportunity for taking a survey of the progress which India and our Colonial possessions have made in that period in material wealth and industrial advancement, and my official connection with both these Exhibitions, and half a century's acquaintance and advocacy of Colonial interests, have given me some advantages in judging.

I have been somewhat superseded by my friend Dr. Mann, in his paper on the Colonies read before the Society in February, but he confined himself mainly to the present position of our various possessions. Our figures differ somewhat, which probably arises from their being taken from different sources. I have compiled mine, wherever possible, from the official Colonial returns, which vary frequently from the digests made for the Government statistical abstracts in this country.

The elements of this inquiry are so numerous, and the field of investigation so vast, from the number of Colonies to be dealt with, that it is impossible to do full justice to the subject in the limited time at my disposal, and the mass of figures to be dealt with is, moreover, so extensive that I must content myself with placing on record for reference the voluminous official statistics, merely summarising the results in groups of Colonies, and dwelling chiefly upon the more important and striking points of progress in population, revenue, public works, principal productions, external commerce, &c.

In the period under review, many things have contributed largely to help on the progress of the Colonies; among these may be named the completion of the Suez Canal, the great improvements made in steam communication, the extension of submarine cables, land telegraphs, and railways, the flow of emigration, and the continuance of gold discoveries in our Australasian colonies.

The children of the parent State, who have gone out from time to time to establish themselves in different parts of the world, having most of them arrived at mature age, now present themselves to the mother country with striking evidences of the progress which, by energy, perseverance, and industry, they have accomplished.

At previous Exhibitions, here and elsewhere, the Colonies have only played a subordinate part in competition with the older European States; but now, responding to the call of the Royal President both of this Society and of the Colonial Exhibition, they fill an exhibition entirely by themselves, and show the abundance of the natural riches and manufactures of the several Colonies Britain has founded, or acquired, in the east and the west, the north and the south, where the British flag waves proudly with all its surroundings of law, loyalty, and freedom.

If we turn first to the feature of *Emigration*, we find from the official returns that about 5,000,000 souls have left our shores in the twenty-five years, of whom 629,036 have gone to British North America, 815,651 to Australasia, 322,480 to the Cape, India, and a few foreign States, in all 1,767,167; this is not one half, however, of the number who left for the United States, the emigrants to the American republic having amounted in that period to 4,200,044, many of these, however, were foreigners.

The poet Wordsworth, in his "Excursion," well remarks:—

> "The wide waters open to the power,
> The will, the interest, and appointed needs
> Of Britain, do invite her to cast off
> Her swarms, and in succession send them forth.
> Bound to establish new communities
> On every shore whose aspect favours hope,
> Or bold adventure, promising to skill
> And perseverance their deserved reward."

However numerous the emigrants may be to our northern and southern colonies, there is room enough for all, there is employment enough for all, and there is, moreover, liberal remuneration for labour, and certain competency in store for honest industry and steady application.

> "Freemen of England, nourish in your mind
> Love for your land; though poor she be and cold,
> Impute it not to her that she is old,
> For in her youth she was both warm and kind.
> True, it fits not that you should be confined
> Within a grudging Island's narrow hold,
> That bred, but cannot feed you. O be bold;
> Blue heaven has many an excellent fair wind;
> Steer, then, in multitudes to other land,
> Work ye the field, the river, and the mine,
> Smooth the high hill, and fell the long-armed pine,
> Till all God's earth be honourably manned."

In 1861, we possessed 2,133 steam vessels, of 506,308 tons; in 1883, 6,241 = 3,725,229 tons. It will thus be seen that we have trebled the number, whilst the tonnage has increased sevenfold.

In 1861, our imports from India and the Colonies were to the value of £52,676,010.

In 1884, we received from India and the Colonies produce and specie to the value of over £92,500,000, distributed as follows:—

		£
India and the Eastern Colonies	..	43,190,555
Australasian ,,	..	27,059,538
African ,,	..	5,372,000
North American ,,	..	9,311,981
West Indian ,,	..	4,483,537
European ,,	..	3,120,319
		92,537,930

The tonnage entered and cleared with cargoes from British possessions in 1885 was 9,739,456.

If we look at what has been done in ocean and land *Telegraphs*, we shall be surprised at the wonderful progress that has been made in the means of rapid communication with our distant Possessions, all of which are brought now within an hour or two of transmission and reply. Ocean telegraphs have been laid across the Atlantic to our North American colonies, in the Mediterranean from Gibraltar to Malta and Cyprus, from Aden to India, across the Bay of Bengal to Singapore and Hong Kong and Borneo, to North Australia, across Bass's Straits to Tasmania, and we can now communicate hourly even with New Zealand.

The land wires are even more important. India, which in 1861 had only about 1,000 miles of wire, has now upwards of 23,000 miles of telegraph, and the Eastern colonies about 1,500 miles more. Australasia has more than 33,000 miles, Canada 17,000, and South Africa about 8,000, besides small extents in the West Indian colonies.

If we pass on to *Railways*, which have done so much to open up unsettled districts, and to afford cheap communication with the seaboard, we find even more startling progress has been made in the quarter of a century; and this has been money well laid out, both in giving employment to labour and manufacturers, and in the result of the remunerative traffic obtained.

In 1861, India had little over 1,000 miles of railway, Victoria 250, South Australia 56, New South Wales 73.

In 1860, the first lines of railway were commenced in Mauritius. A line of 74½ miles, between Kandy and Colombo, Ceylon, was opened in 1867. What do we find in operation now, independent of the many miles of lines in course of construction? The official returns for 1884 show that India had over 12,000 miles of railway, and Ceylon and Mauritius 270; the Australasian colonies 7,500, the Dominion of Canada 9,600, South Africa 1,750, and the West Indian colonies 130.

The Gold produced in the Australasian colonies since the first discovery in 1851 to 1884 has been as follows, as near as can be determined:—

Colonies.	Ounces.	Value. £
Victoria to 1885	54,500,000	218,000,000
N.S. Wales	9,995,825	37,142,631
Queensland	4,529,280	18,117,120
South Australia	89,720	343,950
Tasmania	289,151	1,115
New Zealand	10,552,279*	42,327,907†
Total	79,457,624	315,932,723

The quantity from Queensland is all since 1867, the Tasmanian production dates from 1866, that of New Zealand from 1862, of South Australia from the Northern Territory 1881. Of this quantity there was received at the Sydney Mint, for coinage, from its opening in May, 1857, to the end of 1884, 14,108,558 ounces, valued at £53,657,836, of which there was minted into coin £50,974,000, and into bullion £2,612,404. This go'd was produced in the colonies in the following proportions:—

	Ounces.	Value. £
New South Wales	6,808,290	26,044,614
Queensland	3,662,025	13,050,499
New Zealand	2,024,322	7,988,898
Victoria	1,437,954	5,905,726
Tasmania	6,115	23,625
South Australia	22,885	82,800
Total	13,961,591	53,096,162

There was received at the Melbourne branch Mint from its opening in June, 1872, to the end of 1884, 7,386,639 ounces of gold, value £18,621,752, of which £26,338,100 was issued in coin, and the rest in bullion. Of this total amount of gold, 5,000,000 ounces were raised in Victoria and 1,000,000 ounces in New South Wales.

The gold produced in New South Wales from 1851 to 1884 was 9,538,691 ounces, value £35,361,550, of which £26,044,614 was coined at the Mint, and £9,316,936 exported without passing through the Mint. Besides this, large quantities are said to have passed out of the colony in private hands. Of the total gold raised in this colony, over £29,000,000 in value has been obtained in the quarter of a century under notice.

From the Dominion of Canada in the last thirteen years there has been exported gold-bearing quartz, gold-dust, and nuggets to the value of £3,000,000 sterling. Last year 21,000 ounces of gold were obtained in Nova Scotia alone.

The official Board of Trade returns give the approximate estimate of the value of the gold shipped from the Australasian colonies as follows:—

	Gold. £	Gold Bullion and Specie. £
1855	11,067,667	..
1856	12,245,377	..
1857	11,329,537	..
1858	11,419,852	..
1859	11,640,788	..
1860	10,186,183	..
1861	10,916,015	11,871,870
1862	10,455,126	12,213,964
1863	11,468,833	12,676,361
1864	9,025,032	12,452,473
1865	9,533,640	12,226,136
1866	9,616,442	13,355,136
1867	8,783,489	11,933,832
1868	9,351,191	13,708,717
1869	10,382,955	13,214,612
1870	8,237,367	11,365,326

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* To 1884. † To 1885.

	Gold.	Gold Bullion and Specie.
	£	£
1871....	7,605,898	12,742,333
1872....	7,597,021	10,720,589
1873....	9,369,130	12,061,054
1874....	7,662,925	10,433,717
1875....	6,949,516	9,988,025
1876....	5,793,374	8,214,615
1877....	7,295,868	9,944,005
1878....	5,567,084	8,371,133
1879....	2,403,212	5,865,526
1880....	4,170,749	7,235,612
1881....	6,461,388	9,128,567
1882....	5,087,625	7,743,569
1883....	5,180,741	7,652,700
1884....	3,000,000*	5,063,556
	250,105,425	250,183,428

Coal.—It is a fortunate circumstance that, with few exceptions, wherever British colonies have been founded, there has also been found a local supply of coal.

In North America, commencing with Nova Scotia, Newfoundland, and in various parts of the Dominion of Canada, coal has been found. In Southern Africa it is met with in the Cape and Natal. Many of our southern colonies have valuable coal fields, as in New South Wales, Queensland, Tasmania, and New Zealand. Then we have a coal field in Labuan. Coal is the most abundant of the minerals in New South Wales. For hundreds of miles the coast districts may be said to be one vast coal field. The principal collieries worked are, however, in Newcastle. The quantity raised in the New South Wales collieries, from 1860 to 1884, exceeded 29,250,000 tons, of which 18,000,000 tons were exported. The output, which in 1860 was only 368,000 tons, had risen in 1884 to nearly 2,750,000 tons.

The coal mines of Nova Scotia, which, twenty-five years ago, barely supplied 500,000 tons of coal, have now doubled their produce, the quantity raised last year being 1,000,254 tons.

Coal seams are exposed in more than a dozen different places on the east coast of Vancouver, and about 40,000 tons a year are regularly raised. The existence of a fine quality of coal on the seaboard is of the greatest importance now that the Canadian Pacific Railway has converted British Columbia into one of the world's highways.

In Bengal there are eighty collieries, but only three or four out of the numerous coal-fields known are actually worked. The total output last year was 1,316,000 tons. The Assam coal-fields, which have just been prospected, are also considered very promising; they cover a plateau with an area of thirty square miles. The first colliery in India was only commenced about 1869.

Entering now upon a detailed description of Colonial progress, little need be said of our European possessions, except to mention that we have given up the Ionian Islands and acquired Cyprus. Gibraltar and Malta are mere *entrepôts* for passing commerce, but their relative importance has grown with the traffic through the Suez Canal. The same remark applies to Aden, a dependency of the Indian Empire.

The comparative progress in our European possessions (excluding the Channel Islands and the Isle of Man) has been as follows:—

EUROPEAN POSSESSIONS.

	1861.	1884.
Population	395,384	363,140
Revenue	£175,831	£266,073
Tonnage	3,844,337	18,256,226
Imports ..	£4,183,850	£13,343,789
Exports ..	£3,278,243	£12,908,492

If we turn to the group of India and the Eastern colonies, we find that on the Continent the kingdom of Burmah has now been added to our territory, and besides Sarawak, which may be considered British, we have a new possession in North Borneo.

INDIA.—Steady and rapid progress has been made in British India, both in old and new industries.

There are 3,420 tea plantations in India, which shipped 68½ million pounds of tea last year, besides what was locally consumed. There are 45,000 coffee plantations, which produced 30,742,954 lbs. of coffee, and there are now 2,269 acres of Government plantations under culture with chinchona.

The export of jute, which is so essential to the prosperity of Dundee, has increased from 1¼ million cwts. to 8¼ million cwts.

In Bengal there are twenty-one jute mills working, with 6,139 looms, employing 47,868 hands.

Cotton spinning centres round Bombay and jute mills round Calcutta. There are seventy-four cotton-mills working by steam, with 16,251 looms, 1,895,284 spindles, and employing daily 61,386 hands. These mills consume about 168,000,000 lbs. of cotton. Besides the large home consumption of cotton fabrics, these are shipped to foreign countries to the value of nearly £3,000,000 sterling.

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* Estimated.

In the ten years ending 1873, the foreign trade of India increased but 1 per cent.; in the next ten years, concurrently with the development of traffic through the Suez Canal, it has advanced 61 per cent. The excess of exports of merchandise over imports in 1884, which is a signal feature of Indian trade, was the largest that has yet been reached, the excess being £35,331,906.

The progress made in the external commerce of British India is best shown by a comparison of the exports of the principal articles of produce in 1861 and 1884.

		1861.	1884.
Coffee	cwts.	192,015	328,317
Cotton	,,	3,527,670	5,066,057
Indigo	,,	79,021	154,629
Rice	,,	15,808,000	3,051,532
Wheat	none	.. ....	15,854,292*
Opium	chests	65,369	86,578
Seeds	cwts.	2,497,577	18,267,129
Silk raw ..	lbs.	1,101,844	531,205
Tea	,,	2,220,886	64,162,055
Wool......	,,	17,762,415	18,928,173
Hides & skins	cwts.	.. ....	778,994
Jute	,,	1,232,279	8,368,686

Comparative Summary of the Eastern Possessions.

	1861.	1884.
Population ..	145,905,272 ..	203,840,366
Revenue	£44,424,630 ..	£74,630,192
Tonnage	7,232,420 ..	24,873,975
Imports	£48,452,177 ..	£94,692,892
Exports	£45,343,562 ..	£113,547,325
Railways, miles	1,028 ..	12,004
Telegraphs, ,, ...	11,030 ..	23,207

In Ceylon the planters, finding coffee, cinnamon, and other old products less profitable than formerly, have entered upon new industries, such as tea, chinchona, &c. The coffee export has fallen from 550,317 cwts. in 1861, valued at £1,662,874, to 299,396 cwts. in 1884, valued at £1,106,020.

MAURITIUS has kept steady in its sugar production, and strangely enough the value has been maintained, as it produces a superior quality of crystalised, which found its market, until lately, chiefly in Australia.

The exports were:—

	Cwts.	Value.
1861 ..	2,233,468 ..	£1,771,867
1884 ..	2,503,165 ..	£3,572,683

Reviewing next the position of the Australasian Colonies, we find that there the greatest advance of all has been made in prosperity. We have added to our possessions in the Pacific, the Fiji Islands and part of New Guinea.

A few figures will indicate the enormous advance in the pastoral wealth of the Australasian colonies. Their mineral wealth I have already briefly alluded to. There are so many prosperous colonies in that quarter, that I cannot do anything like fair justice to their individual progress.

The *Wool* exports from India and the Colonies were, in 1861 and 1884, as follows:—

	1861. lbs.	1884. lbs.
India	21,385,429 ..	25,540,253
Australasia	73,294,839 ..	444,255,099
Natal	647,679 ..	17,330,981
Cape Colony	24,873,269 ..	37,270,615
Canada	1,554,588 ..	1,539,421
	121,555,904 ..	525,936,370

Australasian Wool Shipments.

Colonies.	1861.	1884.
New South Wales ..	12,745,891 ..	173,986,303
Victoria	23,923,195 ..	119,542,407
Queensland	6,994,033 ..	35,525,977
South Australia	14,575,101 ..	16,816,068
Tasmania	2,294,269 ..	8,215,101
New Zealand	7,855,920 ..	81,139,028
Total	68,388,409 ..	435,224,884

The advance in the pastoral interests is best shown by the increase of cattle and sheep:—

Number of Cattle and Sheep in the Australasian Colonies in 1861.

Colonies.	Cattle.	Sheep.
Victoria	628,092 ..	6,239,258
New South Wales	2,271,923 ..	5,615,054
Queensland..........	560,196 ..	4,093,381
South Australia	265,434 ..	3,638,356
Tasmania	113,000 ..	1,600,000
New Zealand	193,285 ..	2,761,583
Total....	4,031,930 ..	23,947,632

Other Colonies in 1861.

Cape Colony	..	10,000,000
Falkland Isles	28,526 ..	11,500

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* 21,000,000 cwts. of wheat were shipped in the previous year.

NUMBERS IN AUSTRALASIA, 1884.

Colonies.	Cattle.	Sheep.
Victoria	1,287,947	10,637,412
New South Wales	1,336,329	30,379,871
Queensland	4,266,172	9,308,911
South Australia	389,726	6,696,406
Western Australia	71,102	1,547,061
Tasmania	128,834	1,720,027
New Zealand	698,637	14,056,266
Total	8,178,737	74,345,954
Fiji	5,324	5,373
Total	8,184,061	74,351,327

Other Colonies, 1884.

	Cattle.	Sheep.
Cape Colony	1,500,000	12,000,000
Falkland Isles	16,450	410,100
Ceylon	963,896	53,757
Mauritius	15,000	30,000
Natal	575,698	560,632
Dominion of Canada	3,514,989	3,048,678
Jamaica	84,206	20,000

India and the Colonies also possess a large number of horses, goats, and other stock which I have not thought it necessary to enumerate. The numbers of sheep would have been much larger but for the enormous loss of about 6,500,000 by drought in New South Wales and Queensland. As it is, the number of sheep in Australasia now about equal those in the River Plate States. Canada and India also largely swell the wool production for the supply of Europe.

The following figures mark the progress in NEW SOUTH WALES :—Under crop, 297,575 acres in 1861, and 852,017 acres in 1884. Coal raised in 1861, 342,067 tons; in 1884, 2,749,109 tons.

The great factories and works, which numbered only 788 in 1861, were 22,008 in 1884.

The tallow rendered down in 1860 was 60,638 cwt. In 1848 and 1849 the quantity shipped was 371,981 cwt.; in 1880, 252,826 cwt.; and in 1884, 131,041 cwt.

The boundaries of SOUTH AUSTRALIA have been largely extended by the addition of the Northern territory, so that the colony now extends across the Continent to the Indian Ocean, and the gold discoveries there will hasten on the progress of settlement and pastoral operations. The wheat production in 1884 was 14,621,755 bushels; the land under culture 53,443,411 acres.

The mineral produce of copper, lead, &c., exported, averaged in the five years ending 1867, £685 750 per annum. In 1861, the value of mineral produce shipped was £452,172; in 1884, it was £536,059.

The wool shipped from South Australia in 1861 was but 27,257 bales; in 1884 it was 118,357 bales, valued at £2,618,626.

There are about 1,300 camels in the colony, 109 were first introduced in 1866; they were employed in conveying material for the construction of the Adelaide and London telegraph line in 1872. During the drought in 1881, a large number of these were the means of saving the lives of the starving population in the Albert gold fields of New South Wales.

QUEENSLAND.—This colony has made rapid strides; its population has increased from 34,367, when it was separated from New South Wales, to 310,000 last year. Its revenue has risen from a quarter of a million to 2¾ millions; its exports exceed £4,000,000 in value, and its imports £6,000,000. The area of land alienated is 7,100,000 acres. It produced, besides wine, in 1884, 133,768 galls. of rum, and 1,006 galls. of brandy. The minerals raised in the year were—

	Tons.	Value.
Copper	1,653	30,872
Tin	15,347	134,867
Galena	4,303	36,097
Coal	129,980	54,160

The gigantic strides made by the Colony of VICTORIA are best shown by the following figures. Melbourne, as a shipping port is, after Sydney, the great depôt for British goods for transmisssion to the other colonies and for shipments to Europe:—

	1861.	1884.
Population	220,076	961,276
Revenue	£2,952,101	£5,934,687
Acres under culture	439,895	2,215,923
,, wheat.	196,922	1,104.392
Cattle	628,092	1,297,546
Sheep	6,239.258	10,739,021
Tonnage, in and out	1,090,002	12,964,33
Imports	£13,532,452	£19,201,633
Exports	£13,828,606	£16,050,465
Wool (lbs.)	23,923,195	109,615,884
Tallow (lbs.)	4,208,960	14,960,960
Flour mills	104	140
Manufactories, &c.	429	2,637

TASMANIA and WESTERN AUSTRALIA call for little special notice. The first-named is not very progressive, but the latter is waking up to energy in railway enlargement, and in the utilisation of its vast forests of magnificent woods, of which noble specimens are shown in the Western Australian Court of the Colonial Exhibition, and sheep runs will soon be more extensively occupied there.

The official announcement, published to-day, of the bringing in of 4,000 ounces of gold discovered in Western Australia, will do much now to draw the population thither.

The progress made by the colony of NEW ZEALAND is perhaps one of the most remarkable on record. I can remember the time when the ships with the first colonists, sent out under the auspices of the New Zealand Company, slipped out in the night from the River Thames, in spite of the embargo put on them by the Government. This is within half a century, and now we find a population of 576,284, exclusive of the natives. The number, in 1861, stood at 79,711, and this increase dates from Sir George Grey's Government. In the fifteen years ending 1884, the number of immigrants to New Zealand has reached 265,850. The colony possesses 1,643 factories and works of different kinds, employing 16,600 hands. These comprise 106 printing establishments, 40 flax mills, 100 breweries, 131 grain mills, 223 saw mills, 119 fellmongeries, tanneries, and wool-washing establishments, 127 brick and tile works, 84 quarries, and 80 aerated water and cordial manufacturers.

Coal mining was only commenced in 1867, but will, ere long, become one of the great industries of the colony; between 1867 and 1884, 3,000,000 tons were raised, and the Collingwood Coal Mining Company is now raising 30,000 tons yearly; out of 300,000 tons annually produced 5,000 to 6,000 tons are shipped. The colony will soon produce enough coal for all its local wants, some 600,000 to 700,000 tons, as already half that quantity is produced. There are 51 collieries working.

If we look at the present exports, they consist of 81,000,000 lbs. of wool; 151,000 cwt. of tallow; nearly 10,000,000 rabbit skins; 300,000 cwt. of preserved and frozen meats; 6,000 to 7,000 tons of coal. Timber to the value of £152,000; and kauri gum to the value of £342,000. The shipments since 1861 of this latter resin, so useful for varnish, have amounted to 100,440 tons; value £3,695,563, and it is worth at present £53 10s. a ton.

Instead of boiling down sheep for their tallow, several of the Australasian colonies have tried to supply Europe with meat, fresh and preserved.

In 1880, no less than 41,600 sheep were boiled down in New Zealand, and there were forty establishments devoted to this business and meat preserving. In the last ten years New Zealand shipped preserved meat to the value of £500,000. Commencing with shipment of frozen carcases of sheep in 1882, to the value of £20,000, the shipments, in 1884, from this colony reached a value of £345,000; and in the first nine months of last year 232,095 cwt. were sent to England, of the value of £297,036. Nearly 10,000,000 bushels of wheat were raised in 1884, and the value of the flour and grain exported was £818,687.

Gold was not practically worked in New Zealand until early in 1862, when the mines at Coromandel first attracted attention, but by December the population of Otago had increased from 12,000 to 30,000, and the escorts had brought in by the end of the year 187,696 ounces of gold; this district still forms the chief centre of true lode mining operations. The yield from those mines was, up to 1880, over £4,500,000 sterling, but this is small as compared with the quantity of alluvial gold obtained in the South Island, subsequent to 1861, at which date the gold-fields of Otago became prominently known. In 1864, the gold fields near Hokitaka proved a great attraction to the mining population. The total quantity of gold exported from New Zealand, up to 1884, was 10,552,279 ozs., valued at £41,379,292, and the shipments last year were to the value of £948,615, bringing up the total to £42,327,907.

The Australasian colonies had under culture with wheat, in 1884, 3,658,996 acres. They raised 45½ million bushels of wheat, 15 million bushels of oats, 6½ millions of maize, 2½ of barley. They had 7¾ million acres in all under tillage. The shipping inwards and outwards at their ports reached 11¼ million tons. Their exports of home produce exceeded 54½ million pounds, and their imports were to the value of 64 millions, the great bulk obtained from England. The average taxation in those colonies is about £2 15s. per head.

Wine is a colonial product which is making fair progress. There are four Australian colonies which have given prominent attention to vineyards—New South Wales, South Australia, Queensland, and Victoria. In Western Australia very little wine is produced.

1861.

	Acreage.	Gallons of wine.
Victoria	1,338	47,568
New South Wales	1,583	90,791
South Australia	3,180	122,087
Queensland	40	..
Total	6,141	260,446

1884.

	Acreage.	Gallons of wine.
Victoria	9,095	763,823
New South Wales	4,584	441,612
South Australia	4,590	473,585
Queensland	1,286	95,358
Western Australia	687	81,753
Total	20,242	1,856,128

The Cape Colony had 18,177 acres under vineyards in 1875, and 4,485,665 gallons were produced, but I have no later return.

Cyprus is a wine-producing country. New Zealand and Tasmania produce a little wine, but not to any extent worth mention.

In 1885, we received 46,796 gallons of wine from the Cape and 63,295 gallons from Australia. The Australians are pushing the sale of their wines in India and other quarters, but the high duties are against their introduction into this country.

Coming next to the African Colonies, NATAL has been well described by Dr. Mann, in his paper already alluded to.

The following figures give a comparative summary of the position of the African Colonies at the two periods under notice. I have included the Falklands with them as they can scarcely be placed in any other group:—

AFRICAN COLONIES.

	1861.	1884.
Population	627,135	2,481,897
Revenue	£955,833	£8,449,263
Tonnage	1,069,526	3,562,660
Imports	£3,603,670	£8,801,287
Exports	£2,613,091	£7,023,267

If we compare the progress the CAPE COLONY has made, we find that British Kaffraria was absorbed in 1861, Basutoland in 1868, Griqualand East in 1875, Griqualand West in 1876, and the Transvaal in 1877. In 1861, the colony had only 50 miles of railway, and 781 miles of telegraph wire; in 1884 it had 1,545 miles of railway, 4,209 miles of telegraph with 8,663 miles of wire.

In 1861 the shipments of Cape wool were 24,823,284 lbs., and in 1884, 37,270,615 lbs. Wine and brandy were shipped in 1884 to the value of £18,000. The shipping entered and cleared was 5,322,177 tons. The exports were to the value of £4,138,385, inclusive of diamonds; the imports, £5,249,000.

The wool shipments from the Cape Colony have risen from 24,873,269 lbs. in 1861, to 37,270,615 lbs. in 1884.

In the Cape Colony, if the progress in sheep farming has not been so rapid as in the Australasian colonies with their wider extent of territory and larger influx of immigrants, it has not remained stationary, and two new industries have been developed which have added largely to their prosperity, these are ostrich farming and the discovery of the diamond fields. The export of ostrich feathers in 1861 was only 3,425 lbs., valued at £784; in 1884, owing to the attention given to domestic rearing of the ostrich, the shipments reached 233,411 lbs., valued at £4,329,355. As I read a paper before the Society in 1876, on "Ostrich Farming," it is not necessary here to dwell upon this industry. Copper mining and coal mining have been much developed. in 1861, only 2,197 tons of copper ore were shipped, now the annual production exceeds 21,000 tons. Coal is raised to the amount of 9,000 tons annually, and is likely to progress.

The *Diamond* discoveries of this colony are the most remarkable feature. Commencing with a shipment of the value of £500 in 1868, the exports reached a declared value of £2,807,329 in 1884. The shipments through the banks of Kimberley alone in 1884 being 1,972,134 carats, and the total exports 2,263,734 carats. The estimated value of the diamonds sent away between 1868 and 1884 is £31,672,576, but many were taken also by private hands. The diamonds obtained from alluvial diggings in 1884 were of the approximate value of £51,480, besides the operations of the following mines and diggings:—

	Carats.
Kimberley	642,437
Old De Bow's	497,596
De Tort's Pan	498,550
Bultfontein	566,200
	2,204,783

Our West Indian Colonies have, perhaps, made less progress than any other group of colonies.

The serious depression in the sugar market has placed this chief article of West Indian culture at a great disadvantage in those islands which are mainly dependent upon this product. Their only means of safety is to look around and enter upon other cultures, not in order to supplant the sugar industry, but to supplement their resources.

The most favourable feature in the exports of JAMAICA of late years is the fruit industry. The value of the oranges, bananas, pineapples, and cocoanuts exported in 1884 was £273,534. The fruit industry is fast assuming important proportions, and it now stands above rum and next to sugar. The Bahamas also devote themselves chiefly to pine-apple culture.

I need not speak separately of the other West Indian Colonies, as they are particularised in the tabular returns appended to this paper:—

SUMMARY OF WEST INDIAN GROUP.

	1861.		1884.
Population..	1,107,322	..	1,528,258
Revenue ..	£775,358	..	£2,020,906
Tonnage ..	1,529,750	..	6,316,794
Imports	£5,618,461	..	£9,115,552
Exports	£6,065,964	..	£9,350,73

If we take the article of *Sugar*, we find, by comparison, the exports have been as follows from our Possessions:—

	1861. cwts.		1884. cwts.
India	845,871	..	1,630,520
Mauritius	2,233,468	..	2,473,549
Queensland (26 cwt. in 1871)..			297,474
Fiji	..	..	174,580
Natal..........	15,289	..	235,713
Honduras......	..	..	47,844
British Guiana..	1,302,246	..	2,367,986
W. I. Islands ..	2,600,000	..	4,090,320
Total....	6,996,874		11,317,986

We imported 10,399,405 cwt. of sugar in 1861, and 19,383,746 cwt. last year.

After the repeal of the duty on sugar, the Continent commenced to flood our markets with beet-root sugar, largely fostered by Government bounty. In 1875, 5,325,436 cwt. were imported, and last year we received 11,013,749 cwt. from the Continent.

As I read elaborate papers before the Society last year on "Timber Supplies" and on "Teak Imports and Production in the last 25 years," it is not necessary to go again into detail on the subject of the woods of the Colonies, but the enormous logs and planks, and beautiful specimens of woods and furniture now shown at the Exhibition in the Canadian, Western Australian, New Zealand, Queensland and other Australian Courts, will demonstrate how much they can supply that is useful in this branch of trade.

Our dependence on India and the Colonies for food and other articles is shown by a glance at the statistics of our imports for last year.

We imported from Ceylon and other British possessions 481,422 cwt. of coffee, much more than sufficient for our home consumption of 300,000 cwt.; of tea, 68,635,100 lbs., more than one-third of what we consume; of sugar, about 4,000,000 cwt., only a sixth part, however, of the quantity we import; of wheat, 19,000,000 cwt. from India, Australia, and Canada; of flour, 280,479 cwt. from Canada; of rice, nearly 5,000,000 cwt. from India; 281,720 cwt. of cured fish came from British North America; Canada sent us 68,546 head of cattle and 39,725 sheep; and from Australasia we got 336,495 cwt. of fresh mutton, and 198,279 cwt. of preserved meat; the Dominion of Canada also sent us 606,000 cwt. of cheese. For many important raw materials for manufactures we are also largely dependent on colonial supplies, especially for hides and skins, tallow, palm, and cocoa-nut oil, cotton, jute, and other fibres.

It would seem, however, as if the over production of many important staples of commerce, such as wool, cotton, sugar, coffee, &c., is calculated to reduce the prices so low as to leave a very small margin of profit for the growers, when the cost of production, freight, and interest of capital are taken into consideration. Hence it is wise in many instances to direct attention to new industries, until supply falls to a level with demand.

If, lastly, we glance at our North American group of Colonies, we find their progress resulting as follows:—

	1861.		1884.
Population	3,340,798	..	4,620,314
Revenue ......£	2,846,420	..	7,108,884
Tonnage	5,743,646	..	9,452,712
Imports ......£	13,547,710	..	25,883,097
Exports ......£	11,028,046	..	20,238,931
Railways (miles)	1,900	..	9,575

The Dominion of CANADA was formed on the 1st of July, 1867, of the provinces of Ontario, Quebec, New Brunswick, and Nova Scotia, and the North-West Territory were included in the Dominion in July 1871, and Prince Edward's Island in July, 1873. Newfoundland alone is now separate. I have classed Bermuda among the North American group of colonies.

If we compare the maps of settled Canada and settled Australia now with what they were twenty-five years ago, we shall find territories equal in area to many European kingdoms won from the wilderness, and settled with people, flocks and herds, and prosperous agriculture. We can mark at each successive Exhibition unmistakeable proofs of the rapid progress which nearly all our Colonies are making in the social scale and in material wealth and prosperity.

There are many special features which I have not been able to touch upon in this survey, such as the value of their fisheries, the shipping owned in the Colonies, the textile fibres to be developed, as the aloe fibre in Mauritius, the Rhea fibre in India and the Colonies, the New Zealand flax plant and others; the tanning barks and extracts, some of which have already become important staples—for instance, the hemlock extract of Canada, the mimosa bark of Australia, the myrabolans of India, the gambier of Singapore, &c. Their universities, schools, public libraries, museums, and other kindred institutions, I have not been able to allude to, but I think I have advanced facts and figures enough to show the immense importance of our Possessions and Colonies to the mother country. Their loyalty and desire to aid us have been shown in many important ways; and we shall do well to receive their representatives cordially this year, so as to bind closer the bond of union which links the mother country to the colonies.

EUROPEAN SETTLEMENTS, 1861.

Possessions.	Population.	Revenue.	Tonnage.	Imports.	Exports.
		£		£	£
Gibraltar	15,462	31,597	1,932,697	..	..
Malta	136,339	144,234	798,878	2,947,193	2,377,022
Ionian Islands	236,517	..	1,112,762	1,236,657	901,221
Heligoland	1,500	5,000	..	..	..
Total	389,818	175,831	3,844,337	4,183,850	3,278,243

The Ionian Isles were given up to Greece in May, 1862.

EUROPEAN SETTLEMENTS, 1884.

Possessions.	Population.	Revenue.	Tonnage.	Imports.	Exports.
		£		£	£
Gibraltar	18,381	45,504	9,219,909	..	..
Malta	156,675	212,569	9,036,317	13,343,789	12,908,492
Cyprus	186,304	..	..	385,000	319,000
Heligoland	2,000	8,000	..	..	..
Total	363,360	266,073	18,256,226	13,728,789	13,227,492

Cyprus was acquired in 1878.

EAST INDIAN POSSESSIONS, 1861.

	Population.	Revenue.	Tonnage.	Imports.	Exports.
		£		£	£
British India	143,271,210	42,903,234	3,104,595	34,170,793	34,090,154
Straits Settlements	282,831	151,016	1,369,094	7,917,210	6,579,726
Ceylon	1,919,487	751,997	837,221	3,663,750	2,706,207
Mauritius	310,050	482,789	600,415	2,647,289	1,952,781
Labuan	2,373	8,353	10,712	53,146	14,694
Hong Kong	119,321	127,241	1,310,383	3,587,000	1,052,000
Total	145,905,272	44,424,630	7,232,420	52,039,188	46,395,562

The Straits Settlements were transferred from the Indian Government to the Colonial Office in 1867.

East Indian Possessions, 1884.

Possessions.	Population.	Revenue.	Tonnage.	Imports.	Exports.
		£		£	£
British India	204,000,000	71,727,421	7,250,603	68,156,654	89,098,427
Straits Settlements	540,000	629,921	6,343,718	18,676,766	17,260,138
Ceylon	2,763,000	1,162,722	3,510,566	4,811,451	3,161,262
Mauritius	370,666	860,958	759,412	2,963,152	3,941.757
Labuan	6,298	4,780	47,918	84,869	85,741
Hong Kong	160,402	244.390	6,961,758	..	..
North Borneo	..	..	..	..	..
Total	207,840,366	74,630,192	24,873,975	94,692,892	113,547,325

Australasian Group, 1861.

Colonies.	Population.	Revenue.	Tonnage.	Imports.	Exports.
		£		£	£
New South Wales	358,278	1,448,610	745,696	6,391,555	5,594,839
Victoria	541,800	2,952,101	1,090,002	13,532,452	13,828,606
Queensland	34,367	238,239	109,204	967,951	709,599
South Australia	130,627	575,575	208,895	1,976,018	2,032,311
Western Australia	15,601	67,261	115,256	147,913	95.789
Tasmania	90,211	315,733	230,308	954.517	905,463
New Zealand	162,364	782,021	403,336	2,493,811	1,370,247
Total	1,333,338	6,379,540	2,902,697	26,464,217	24,536,854

Australasian Group, 1884.

Colonies.	Population.	Revenue.	Tonnage.	Imports.	Exports.
		£		£	£
New South Wales	921,268	11,722,334	4,660,958	22,826,985	18,251,506
Victoria	961,276	5,934,687	3,151,587	19,201,633	16,050,465
Queensland	309,913	2,673,554	3,614,264	6,381,976	4,673,864
South Australia	312,781	3,318,929	1,834,532	5,749.353	6,623.704
Western Australia	31,700	290,319	442,886	521,167	405,693
Tasmania	130,541	549,262	614,198	1,656,118	1,475,857
New Zealand	608,304	3,707,488	1,063,430	7,663,888	7,091,667
Fiji	132,700	91,523	137,852	434,000	345,344
Total	3,408,483	28,288,096	15.519,707	64,435,120	54,918,090

AFRICAN COLONIES, 1861.

Colonies.	Population.	Revenue.	Tonnage.	Imports.	Exports.
		£		£	£
Natal	152,704	114,087	36,857	402,689	119,207
Cape Colony	267,096	748,832	628,508	2,605,305	1,972,700
St. Helena	6,860	21,408	155,984	127,850	9,337
Gold Coast	151,346	9,335	41,754	162,970	145,819
Lagos*	..	..	..	..	..
Sierra Leone	41,624	36,461	96,120	168,070	213,204
Gambia	6,939	16,162	68,283	109,581	136,838
Falkland Islands	566	9,548	42,020	27,205	15,986
Total	627,135	956,833	1,069,526	3,603,670	2,613,091

* Only commenced in 1868.

AFRICAN COLONIES, 1884.

Colonies.	Population.	Revenue.	Tonnage.	Imports.	Exports.
		£		£	£
Natal	424,495	610,937	422,785	1,675,850	957,918
Cape Colony	1,249,824	7,533,591	1,565,649	5,270,697	4,224,455
St. Helena	5,059	9,971	125,571	63,786	23,406
Gold Coast	651,000	125,956	500,547	527,339	467,228
Lagos	75,270	57,932	383,571	538,221	672,414
Sierra Leone	60,546	76,210	382,325	455,424	377,055
Gambia	14,150	24,959	150,791	212,122	199,483
Falkland Isles	1,553	9,687	31,421	67,848	101,338
Total	2,481,897	8,449,263	3,562,660	8,801,287	7,023,297

WEST INDIAN GROUP, 1861.

Colonies.	Population.	Revenue.	Tonnage.	Imports.	Exports.
		£		£	£
Bahamas	35,487	40,156	80,882	274,584	195,584
Turk's Island	4,372	8,749	86,132	26,568	25,031
Jamaica	441,255	275,027	197,376	1,089,482	1,214,614
Virgin Islands	6,051	2,730	9,255	9,830	20,848
St. Kitts	24,440	20,283	51,885	136,938	158,225
Nevis	9,822	6,378	11,980	33,184	40,319
Antigua	36,412	37,874	64,261	208,678	237,123
Montserrat	7,645	4,266	16,119	24,719	21,048
Dominica	25,065	12,527	19,768	55,755	100,379
St. Lucia	26,705	14,227	24,783	110,063	96,321
St. Vincent	31,755	20,851	37,398	125,906	183,676
Barbados	152,727	98,049	262,035	923,875	1,075,375
Grenada	31,900	16,728	41,935	114,252	112,464
Tobago	15,410	8,266	12,372	56,442	63,170
Trinidad	84,438	171,729	196,981	856,727	645,362
British Guiana	148,026	301,761	344,417	1,399,713	1,583,649
British Honduras	25,635	35,757	60,140	231,744	292,576
Total	1,107,145	775,358	1,516,819	5,669,460	6,065,764

WEST INDIAN GROUP, 1884.

Colonies.	Population.	Revenue.	Tonnage.	Imports.	Exports.
		£		£	£
Bahamas	43,521	40,475	222,122	181,494	122,351
Turk's Island	4,732	10,474	256,362	26,623	34,035
Jamaica	580,804	579,720	969,549	1,568,639	1,483,982
Virgin Islands	5,287	1,859	10,381	7,239	3,488
St. Kitts	29,137	43,209	397,012	213,583	205,497
Nevis	11,864				
Antigua	34,964	45,296	381,266	169,501	177,808
Montserrat	10,818	5,934	75,564	25,598	32,678
Dominica	28,840	18,013	263,087	60,536	47,288
St. Lucia	40,681	46,118	422,001	146,460	145,865
St. Vincent	43,039	34,068	160,384	122,626	114,907
Barbados	171,860	145,297	807,104	1,156,230	1,318,879
Grenada	45,495	50,216	258,508	153,421	213,118
Tobago	19,075	11,371	107,570	32,746	41,619
Trinidad	166,628	476,058	1,048,959	3,083,870	2,769,727
British Guiana	264,061	460,932	695,238	1,999,448	2,322,032
British Honduras	27,452	51,866	241,687	227,538	317,449
Total	1,528,258	2,020,906	6,316,794	9,185,552	9,350,730

NORTH AMERICAN COLONIES, 1861.

In arriving at the comparative figures of 1861, for what is now the Dominion of Canada, we must summarise the returns of the separate provinces or colonies of which it is now composed. These are as follows :—

Colonies.	Population.	Revenue.	Tonnage entered and cleared.	Imports.	Exports.
		£		£	£
Canada	2,506,755	2,322,524	2,136,795	8,969,756	7,627,957
New Brunswick	252,047	145,594	1,471,410	1,238,133	947,091
Nova Scotia	332,264	146,050	1,392,345	1,522,645	1,154,867
Prince Edward Island	80,857	28,006	166,738	209,936	163,114
British Columbia	11,816	58,396	31,842	282,880	12,686
Vancouver's Island	23,000	36,221	172,365	416,611	—
	3,206,739	2,736,791	5,371,495	12,639,961	9,905,715
Newfoundland	122,638	128,469	352,987	1,152,857	1,092,551
Bermudas	11,781	17,381	91,529	164,503	29,780
Total	3,341,158	2,882,641	5,816,011	13,957,321	11,028,046

1884.

North American Colonies.	Canada.	Newfoundland.	Bermuda.	Totals.
Population	4,408,094	197,332	14,888	4,620,314
Revenue	£6,836,166	£243,949	£28,769	£7,108,884
Tonnage	8,484,301	726,724	241,687	9,452,712
Imports	£23,917,200	£1,682,457	£283,440	£25,883,097
Exports	£18,782,156	£1,368,153	£88,622	£20,238,931

RAILWAYS.

	1861.	1884.
Eastern:—		
India	1,028	12,004
Ceylon		177
Mauritius		92
		12,273
Australasian:—		
New South Wales	73	1,698
Victoria	250	1,624
South Australia	56	1,059
Western Australia	—	118
Queensland	21	1,207
Tasmania	—	215
New Zealand	40	1,570
Total		7,691
Other Colonies:—		
Dominion of Canada	1,900	9,579
Cape Colony	50	1,545
Natal		116
Jamaica		25
Trinidad		51
Barbados		26
British Guiana		26

LINES OF TELEGRAPH OPEN.

	Miles. In 1861.	Miles. In 1885.	Miles of wire.
Eastern Settlements—			
India	1,000	23,341	68,669
Ceylon		1,151	
Mauritius		70	
Straits Settlements		120	
		24,612	
Australasian Colonies—			
New South Wales		9,755	18,661
South Australia	914	5,292	7,833
Victoria	2,586	4,020	8,055
Queensland	169	6,979	11,299
Western Australia		1,885	1,897
Tasmania		1,417	1,716
New Zealand	40	4,264	10,474
		33,612	
Other Colonies—			
Cape of Good Hope		4,209	8,663
Canada	4,064	17,000	
Jamaica		26	
British Guiana		30	

DISCUSSION.

Mr. LIGGINS wished it were possible for the founders of the Society to hear of the magnificent progress which the Colonies had made in the last twenty-five years, or as he should prefer to put it in the case of Australian colonies, the last forty years. The figures were very instructive and worthy of careful study; the figures giving the products of every kind were simply prodigious, and those showing the advance in steam and other tonnage were on an equally gigantic scale, showing that the industry of those who had left the mother country had been developed in a legitimate manner. But there were other features which had to be seriously considered. How was it that while those who had gone abroad were so flourishing, all at home were suffering from bad trade? The reason was over-production all over the world. It must not be supposed that all these products and this raw material came to this country; he was sorry to say that the exports from all the Colonies to foreign countries were largely increasing, and comparatively there must be a falling off in those sent to England. The prosperity of the Colonies, therefore, might not be an unmitigated blessing. It was recently stated in the *Times* that eleven of the largest steamship companies, one of them the oldest in the world, paid no dividend last year. He knew men who had formerly been prosperous as farmers, who could now hardly make both ends meet; one of them paid £1,000 a year rent, and had been for four or five years keeping his wool stored, because the imports from the Colonies had so knocked down the price, that it did not pay to send it to market. He also knew people of the highest respectability and honour, who were formerly wealthy Liverpool merchants, who failed some years ago in consequence of the over-production of coffee in Ceylon. The tea interest had also been turned topsyturvy in consequence of the large cultivation of it in India; it was now comparatively prosperous, but for many years the capital invested in tea-growing in India was simply lost to England. The same remark applied to sheep farming in Australia; millions had been sunk there because the prices at which the wool and mutton could be sold were not remunerative. He knew all the British West India colonies, which had been enriching this country for 200 years; and, when he was a boy, the very name of West Indian merchant almost indicated a millionaire; but of late the development of the West Indies had been at the expense of English capital; all his capital had been sunk there, in those fertile fields, the most charming on the face of the earth. Demerara was enormously fertile, and its extent was almost unlimited; and he had seen canes growing there 30 and 35 feet high, and as many as 40 from one root. These colonies must devote themselves to sugar growing, for it was only in certain places that anything else could be grown with advantage, and he doubted if it were possible to compete with other countries in the production of pine apples and fruits. Pines would only grow under certain circumstances, and bananas would only grow where there was plenty of water. He had just had letters from Florida, stating that the orange growers there were serious losers, though they had access to the markets of New York, Philadelphia, and Baltimore. With regard to sugar, however, it was impossible to grow it in the West Indies at a profit, in consequence of the bounties given by foreign Governments. Not a month ago a large Russian ship came to London with 1,600 tons of beetroot sugar, on which the Russian Government had paid a bounty of £6 a ton, and how could anyone compete with that. England was in this way losing the West Indies, for last year nearly the whole produce went to the United States, where a rather better price was obtained. The shipping was American, and England thus lost the whole benefit of the trade; in fact, for all useful purposes, she had already lost one of the brightest gems in the British Crown.

Mr. TRELAWNEY SAUNDERS said he could not withhold his meed of praise to Mr. Simmonds, who had added one more proof of the importance of our Colonies to every interest in this country. He had heard with much regret the account given by Mr. Liggins of his experience of investment in the West Indian colonies; but still there could be no doubt that the record which had been placed before them was, on the whole, one of unparalleled success. It might be regretted that individuals should have suffered, while there had been so much general success, and the story just told of the West Indies was a very serious one. All this pointed in one direction, viz., that these important interests ought to be more directly represented in the Legislature. It was because the whole of the Colonial interests were practically unrepresented, that such conditions existed. He had been striving for many years to get the Society and the Colonial Institut, to take up the consideration of some practical measures for bringing about the representation of all Colonial interests in the Imperial Parliament. He did not suppose a solution of the question would be arrived at once, or that the first scheme would be the one ultimately adopted, but he maintained that the figures now brought forward were sufficient proof of the importance of the subject, and of the necessity for its recognition. Unfortunately, everyone was afraid to touch it, though within the last few days he had seen some signs of an awakening to its importance, inasmuch as the London Chamber of Commerce had offered a prize of £50 for the best essay on a practical method of arranging for Colonial representation in the Imperial Parliament. Some were disposed to under-estimate the importance of the Colonies to the mother country, to say that the Colonies would go on as well by themselves, and that England would do as well without them, but he could offer a most cogent fact in disproof of any such idea. The Australian colonies represented a population only one twentieth that of the United States, where was a people of the same origin the same habits, and consuming the same kind of articles, and yet our trade with those Colonies was much greater than with the United States, having twenty times the population. The only explanation was that in the one case the trade was carried on under the same flag and the same general influences; in the other it was carried on under another flag and under adverse influences. Every portion of the United States was represented in Congress and in the Senate, whilst at the same time each division had its own Parliament for local purposes. There were nine Parliamentary divisions of the English monarchy. The greater part of our colonies, including all the West Indian, were under some sort of Crown government, and, where there were Legislatures, a large proportion of the legislators were nominated by the Crown. Nine of the Colonies had, by their own energy, raised themselves to the position of having a Parliamentary system, with responsible ministers for the administration of local affairs; but it would scarcely be believed that these important communities had as yet no voice whatever in external affairs, in deciding on peace or war, which might bring destruction on their shores; in postal arrangements, or in anything which affected their external communication, except such as the Colonial-office might deign to allow them. They could not stand still, and if they were to go on advancing, the political institutions must keep pace with the material progress. Statesmen were too much engaged in party contests instead of statesmanship, and he regretted to see that there was too little disposition on the part of the country to take up this question, and force on their representatives a proper consideration of them.

Mr. COLEMAN said he could not give very much information about the Falkland Islands, which he represented. It was a small Crown Colony with a restricted population, and not much commerce. It was entirely a pastoral country, and was doing fairly well, except that the value of their produce had fallen a good deal lately. Wool was the main article of export; they could not grow any cereals, and had no roads, but there were abundance of ports to which the sheep could be driven, and from thence the wool and skins could be conveyed to the main port and shipped to England. At the present time the colony was self-supporting; they had no minerals, and consequently had to depend on England for fuel; and they were looking forward to the Admiralty carrying out their intention of fortifying the place, and making it a coaling station for the navy. For some years past they had only been able to melt down their surplus sheep, the climate not being so suitable for the manufacture of preserved meat as Australia and New Zealand; but he was happy to say that some mutton was now being refrigerated, and in the course of next month a shipment would arrive, which was reported to be as fine as was ever sent to this country. The population was small, but healthy, consisting mainly of Scotch; and there were no aborigines. The climate was somewhat similar to that of Scotland, and the Scotch liked it; for though they often came back after making a little money, they generally went out again. Both human beings and animals throve well there, and, in fact, one of his shepherds wrote to him saying that it was a paradise for sheep and shepherds.

Mr. RICHMOND HENTY said his family were the first to settle in Victoria, and the first to introduce cattle, sheep, and horses of the best breeds, capital, labour, seeds, and farming instruments. He claimed to be the first white native of the colony of Victoria. His family landed in Victoria with something like forty-five persons, all told, in a little vessel from Tasmania, which was really the parent of most of the Australian colonies, and now the population was over 900,000, though he was not yet fifty years old. That showed the marvellous progress of the colony, which had offered a field to vast numbers of emigrants from Great Britain, and afforded a home and prosperity to all who had been steady and determined to push their way. Thousands, and hundreds of thousands, were now settled there in prosperous circumstances. Highlanders came there with little, and now they were prosperous sheep farmers and agriculturists. Irish also, from all parts, he had found a hard-working, steady, and industrious set. He had found, without exception, that emigrants who put their hands to the plough, and went to work, were prosperous and happy. There was no poverty, and no poorhouse, and the country still offered abundant room for all the surplus population of the old country. There had been an immense deal of distress in England during the last winter, which he was told was one of the severest for twenty years, and he should much like to see some comprehensive system of emigration adopted to the Australian colonies, which afforded unlimited scope for the settlement of the superabundant English population. It appeared to him that, instead of money being given away indiscriminately in charity, if it were all directed to one great common object, in assisting emigration, much more good would be effected. By so doing they would be increasing the population of New Britain, people living under the English flag and English law, and who were as loyal to the Crown and constitution as Englishmen themselves, if not more so. The subject of federation had been earnestly preached in the Colonies, and it was ably assisted in England. He had been very sorry to see that they had lost one of the ablest promoters of that object in the death of Mr. Forster. Not long before he left Australia a great meeting was held in the Melbourne Town-hall, called by the Mayor, which was to be presided over by a native-born Australasian, and all the speakers were also to be natives. He had just got up from a sick bed, but when the chairman of the Native Australasian Association saw him, he compelled him to go on the platform, and he had to propose the last resolution. Various resolutions were carried without a dissentient voice, and the one entrusted to him was that the whole of these resolutions should be combined in one, and sent to the Colonial Secretary for presentation to the Queen. He was just able to do that, and he never heard in all his life such cheering as he did that night from that large gathering of people when those motions were placed before them with the idea of carrying out the federation of the Colonies. The idea was not only federation, but also to encourage Colonial reciprocity with regard to tariffs, and then to extend that so as to create, if possible, a tariff system between those Colonies and the old country, and ultimately to have some representation of the leading politicians of the Colonies assisting in the Imperial Parliament. That idea would apply to every colony under the British flag. If it were done, the interests of the Colonies would be brought before Parliament in such a way that attention would be drawn to the great object in view, which was to have the whole of the Australasian Colonies absolutely united with the Britain from which they sprang. The Colonies were but branches of the mother stem which were growing up to be her support, if a time of need ever arose in contending with the competition and jealousy which existed on the great continent of Europe.

Mr. H. MONCRIEFF PAUL, as an old Australian colonist, regretted that more colonists were not present to hear this interesting paper. It contained voluminous statistics about wool and other products, and it was necessary to remember that wool was, after all, one of the great backbones of the Australian colonies. One gentleman had said that farmers here could not sell their wool, because of the competition of the Colonial product; but if it were so, it was only because the colonial product was superior to that grown here. Colonial wool had made vast progress both in England, in America, and on the Continent, and it would always continue to be an article of increased consumption. When they saw how the Australian sheep had increased, there need be no fear but that their fleeces would be freely used by the nations of Europe and America. They had not yet touched the Eastern nations, but efforts were being made in that direction, and the day would come when they also would develop a demand for woollen materials. Mr. Simmonds had spoken of the River Plate, and the sheep there in comparison with those of Australia, but he would find that the aggregate in South America was about 90,000,000 against about 75,000,000 in the Australian colonies. Still the latter were not afraid of the competition of the River Plate wool, for, though they had passed through a series of droughts in certain parts, which had deteriorated some of the wool, that would soon be got over. There were two other points to be kept in mind, the development of railways and telegraphs. In this country one saw first a turnpike road, and then a railway, and lastly a telegraph, but in Australia it was just the reverse; very often you saw a line of telegraph where there was no road, merely a bush track, the railways followed afterwards, and sometimes in certain parts a road was made. Many a poor wanderer in the bush had found his way to a town by following the telegraph line. Mr. Simmonds had spoken of the wheat which came from India; formerly it could not be brought here at any price below 42s. a quarter, but now it could be delivered here 10s. a quarter cheaper, and one must not suppose that the ryot was a loser by the difference; he really got quite as much as he used to do when it was sold at 42s., because the transit facilities had been so much increased by railways in India, and by cheap steam communication, and the sweeping away of intermediary charges, that the grower got quite as much as he did before, whilst the consumer in England was benefited by the lower price. The same thing applied to Australia; by cheap transit facilities they were able to send to this country products which could not be exported before. Sugar had been imported from Queensland simply from this reason; Mauritius had formerly sent her sugar to Australia, but it was now coming to the mother country, because the Australian colonies were able to draw their supplies from Queensland and Fiji. The great thing wanted in the colonies was increased population. In 1861 it was 1,300,000, and it was now something like 3,300,000, but as Mr. Henty had said what those colonies wanted was population of the real kind. This was a question which would have to come up for consideration, for there was many difficulties arising in England; the Irish difficulty and the Crofter difficulty; but emigration would be a panacea for both. In the Australian Colonies people would find a home and means of providing for their families, and the overcrowded crofts of Scotland and farms of Ireland would be relieved.

The CHAIRMAN said one of the best illustrations of the progress of the Colonies, was the presence of Mr. Henty, the first native citizen of Victoria, and the eloquent part he had taken in the discussion. This subject was very vast, and Mr. Simmonds might well have extended it, even if he had confined his attention to the new products which had been brought forward during the last twenty-five years. Another remarkable circumstance was the change which had taken place in the geographical relations of this country with the Colonies. The Suez Canal had created an immense change in the mode of communication, but now there was the Canadian Pacific Railway, and the new route which was referred to at the last meeting of the Section, the Hudson's Bay route; so that instead of being confined to the intercourse by the Atlantic or by the Red Sea, we should find a new route, and doubtless a new development of trade in connection with it. Something also might have been said about the spread of the English language the establishment of the great English community, not only in speech but in institutions and literature, which had risen in Australia almost in the time of Mr. Henty himself. Now, the improved well-being of the people of India—the remarkable political advancement referred to by Mr. Saunders and other speakers—was not to be forgotten. There seemed a desire on the part of some persons to discourage emigration, because they said there was no field for untrained labour; but he had been much struck with the figures showing the large amount derived from gold-mining and the diamond fields, and the greater part of this was derived from unskilled labour. With regard to over-production, there was no doubt over-production in one sense, but there was something besides that, which at the present moment was affecting the whole relations of society—it was production under cheaper industrial conditions. What Mr. Moncrieff Paul had said with regard to India and Australia had a much wider application. If cheap transit were established into the interior of Australia or India, the articles were produced under cheaper industrial conditions. Medals had been given in the room to Sir Henry Bessemer and Sir William Siemens, and they all looked with pride on their achievments, but what were the results? He could remember when steel was ten times the price it was now, and what was the consequence? When an important material like that was reduced in price, it enabled the successors and imitators of those inventors to run cheap railways into every part of the world, which, under the best conditions of soil and climate, were able to produce wheat, maize, sugar, and coffee. It was not simply a question of over-production, because instead of wool being brought down by waggon from the interior of Australia by a long and painful journey, it was carried cheaply by railway, and when it got to the coast there was a steel steamer ready to bring it to market at the cheapest possible rate. Those were the conditions which caused the great industrial revolution and the depression under which we actually suffered amidst the vast progress which Mr. Simmonds had delineated. In conclusion, he proposed a cordial vote of thanks to Mr. Simmonds for his paper. In former days, he established a colonial organ which was of invaluable service, and they all knew from the *Journal* of the Society what he had done with regard to raw materials, waste products, trade museums, of which he formed the first collection, and industrial and technological science generally. He had been one of the first to lecture in London on the subject, and he only wished the efforts he had so disinterestedly made, had been more adequately appreciated.

The vote of thanks was carried unanimously, and, having been acknowledged by Mr. Simmonds, the meeting adjourned.

NINETEENTH ORDINARY MEETING.

Wednesday, April 14, 1886; Sir FREDERICK ABEL, C.B., D.C.L., F.R.S., Chairman of the Council, in the chair.

The following candidates were proposed for election as members of the Society:—

Bidwell, Miss, 11, Hyde-park-place, W.
Curwen, J. Spencer, Forest-gate, Essex.
Hebson, Douglas, Tower-chambers, Liverpool.
Hookey, James, General Post-office, E.C.
Mount, George, 5, Belsize-park-gardens, N.W.
Salmon, James, 21, Finsbury-pavement, E.C.
Thompson, Charles, St. Niman's-house, Leighton-crescent, Brecknock-road, N.W.
Watson-Will, William, Ossory-villa, Ossory-road, S.E.
Wightman, Charles, 15, Fenchurch-street, E.C.
Williams, Thomas Henry, Bank-house, Garston, near Liverpool.

The following candidates were balloted for and duly elected members of the Society:—

Bazley, Sir Thomas, Bart., Hatherop Castle, Fairford, Gloucestershire.
Christopher, Robert George, 35, Chauntler-road, Custom-house, Victoria Docks, E.
Harland, Robert Henry, 37, Lombard-street, E.C.
Henderson, John, junr., Meadowside Works, Partick, Glasgow.
Ince, H. Osborne, Eltham-lodge, 193, Kilburn-rd., W.
Legg, William A., Liverpool Waterworks, Llanwddyn, Llanfyllin.
Lewis, Henry Frederick William, Lyndham-house, Hampton-road, Redland, Bristol.
Wildy, Augustus G., 13, Furnival's-inn, Holborn, E.C.

The paper read was—

THE TREATMENT OF SEWAGE.*

BY DR. C. MEYMOTT TIDY.

When, some six months ago, your Council did me the honour to ask me to read a paper before your Society on the subject of the "Treatment of Sewage," I accepted with considerable misgivings, knowing that to do the subject in any way justice would necessitate an amount of work which I was not quite sure that I had time for at my disposal. However, I accepted the duty, and I at once set to work to think out the whole matter. I had a vast amount of facts to go over, and the result has been that I have prepared a paper which it is impossible to read for two reasons—first, its length, for I think it would take almost a week to read, and, secondly, that it is not in proper form, which is a very important matter in connection with this subject. I only mention this in order to assure the Society that I have not neglected the subject which I have been asked to bring forward. Perhaps I have done a little too much, so far as that is concerned, in its preparation; and I shall have to ask you to forgive me if, instead of reading the paper, I give an outline of the conclusions at which I have arrived, and of certain facts bearing on those conclusions, and, at the same time, if I avoid, as far as possible, anything like details. These will all be printed in due course, and then the details upon which I have based my conclusions will be before the Society.

I should like to mention one or two other preliminary points. First of all, I have tried to consider this subject unfettered, as far as possible, by previous conclusions. I remember that famous saying of one we know very well, Professor Clifford, that consistency was the bugbear of weak minds. I have not tried to be consistent. I have attempted, at any rate, to approach the subject from the position of judge, if possible, and not from the position of advocate. I come before you without any patent; I am an advocate of no system. I have been retained by a good many people on both sides in my time, and I have had an opportunity of knowing what is going on behind the scenes, and, as I say, I come here to-night without being an advocate of anybody, or anything, without any patent to support, and without, as far as I know, having written anything upon the subject which can be criticised. So that I think I am in a perfectly independent position in this matter. Another matter which I should like to mention is my obligation to many friends in preparing the paper, and I mention that so that it may not be supposed I am taking upon myself credit for work which belongs to others. First of all, I must mention my friend, Professor Dewar, whose originality we all know. Then there are others, earnest, ardent precipitationists, like Mr. Hawksley. I cannot mention all their names at every turn, and therefore I must, once for all, admit the obligations which I owe to them before I start.

Now, I have endeavoured to come to something like a conclusion as to the proportions of solids and liquids in sewage which are contributed daily by a town population of a given number. And I have endeavoured to do this as far as possible by calculations. Those calculations have been made to a great extent at the London Hospital, where we have something like 900 people, and where we have, therefore, a very good opportunity of judging. I am not going through the actual numbers to-night, but I may say that if you take a town population of 10,000 people, you will not be very far wrong in saying that the urine of that 10,000 of town population will be something like 10,300 gallons, of which from 740 to 750 lbs. is organic matter, and of that organic matter it may be taken that about 220 lbs. is nitrogen. Then, as regards the fecal matter, it may be taken that the dry fecal matter from the 10,000 town population will be about 430 lbs. There will be that quantity of dry fecal matter passed per day by that number, and of that quantity about 360 lbs. is organic matter; of that 360 lbs. something like 23½ lbs. is nitrogen. So far as I can make out, that is as nearly as possible the state of facts.

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* The paper as printed is a report, taken down at the time, of what Dr. Tidy said. It is hoped that the full text will be printed in the *Journal* later on.

Now, then, of the constituents of this organic matter, the phosphoric acid and potash have a certain manurial value. This annual value of the excreta has been calculated by a great many different people. I do not know myself very much about the agricultural aspect of the subject, and I have therefore looked up all the estimates of agricultural writers bearing upon it. It is very difficult to make anything of them, for they vary from 6s. 6d. to £1 as the annual value of the excreta of each adult. I think you may take it that between 8s. and 9s. is more nearly the actual result than any other that I can arrive at. Then we have got all sorts of calculations about the ammonia. We are told that urine, on the average, contains 10·3 per cent. My own experiments lead me to think that that is rather a low estimate of the actual quantity—decidedly low I think—when you take into consideration the fact that a large number of the population of towns are, generally, not in very good health, and that the amount of ammonia excreted during disease is not at all the same, but very often double what it is during health; however, that does not make very much difference. Then the value of the ammonia alone is something between 6s. 8d., and 7s. 6d. per year for each adult. All I want to make clear is—for this is the point I wish to arrive at in connection with this question—that the chief subject of manurial value is urine. It is very curious to see all the estimates that have been made of the relative valuations of this excreta. We have, for instance, the statement that a pound of human excrement is equal in manurial value to 13 lbs. of horse dung, or 6 lbs. of cow dung. A very famous chemist has said that the excretal value of one adult is equal in manurial value to the droppings from one sheep, and so on. I can only mention these facts to you as an introduction to my story.

Well, the first calculations with regard to the value and quantities of this excreta were made from the cesspool system and the midden system. The middens were not looked upon as sources of profit, but simply as means to prevent nuisance. Cesspools had many disadvantages; there were noxious emanations from them, polluted wells, and all sorts of things. The middens have their advantages, and they also have undoubtedly their difficulties. One of the difficulties in connection with them was that of educating the people to use them properly; a difficulty which, in my opinion, applies just as much to water-closets as to middens. Another difficulty was to get the local authorities to attend to them properly, I mean with regard to the perfection of the scavenging arrangements; and I am bound to say that, in my experience, the difficulty is not one iota less in getting the local authorities to treat our sewage properly. The middens have two advantages; the first is the diversion of excremental matters from the rivers, and the second, that disinfectants can be used in middens during periods of epidemics. Those are very great advantages which we have to consider in connection with this subject.

Now, there are two matters which I have to mention with regard to a circumstance which was pointed out by Dr. Frankland, which is that sewage from midden towns is just as foul, just as impure, and just as polluting, as the sewage from water-closet towns. And Dr. Frankland, in one of the reports of the Rivers Pollution Commissioners (for, of course, although it was the report of the Commissioners, it was really his report), has given figures to show that the sewage from these midden towns is as bad as that from water-closet towns. I emphatically join issue with him there on the facts. My own experience is that he is absolutely wrong somewhere. I do not know exactly where, but I am perfectly clear that he is wrong, and that midden town sewage is not so bad as water-closet town sewage. And it is a very curious fact also, that it is very clear from Dr. Frankland's own results that his results show he is wrong somewhere, because he has taken this sewage of which he has given the composition from a large number of midden towns; and after giving the details showing that the sewage of midden towns is the same, or rather worse, than the sewage of water-closet towns, he says that the facts also show that an average of 25,561 tons of solid matter is annually kept out of the midden towns' sewage which has been examined. Well, I cannot make out exactly how, having come to the conclusion by elaborate calculations that out of the midden towns sewage which he has examined there is kept out 25,561 tons of solid ewage matter, he can say that the sewage is as bad in the one case as in the others. That is one of many difficulties which I have found at starting. My own calculations show that Dr. Frankland is correct in the quantity of solid matter which is kept out of the sewers, and by that quantity of course is the sewage of the midden towns improved. That is the conclusion at which I have arrived on that point; therefore, I join issue with him, and it is very important that I should join issue with him there, because it is a matter on which I shall have to speak. It is no use saying that middens, if not properly looked after, are a nuisance; of course, anything that is badly looked after is a nuisance. I only say that it is important that we should notice those facts.

It is impossible that I should go here into anything like a discussion of the merits of the dry-earth system. As regards cost, I will simply say this: that two men and one horse can, at any place where the place of collection is ordinarily near a town, collect three pails a week per head at the cost of 3s. 9d. per ton. That seems to be about the result.

And now we come to the water-carriage system. People said, "Here is this horrible stuff to be got rid of; what can there be better to get rid of it than water—wash it away as fast as possible." That was the idea—thus arose the water-carriage system.

And what is the value of the sewage thus produced? Sewage liquid, compound—very compound; complex—very complex. We may say broadly, if we want to define sewage (and I have defined it on many occasions) that it is the refuse of communities, their habitations, streets, and factories. This is not a very accurate definition, but it is somewhere about it. Now, then, as regards the quantity of sewage and the quality of sewage, I think there are two facts to be borne in mind. I have the analyses of sewage from a great many different towns which have come before me, but there are two facts which I want to bring before you, and the first is, that the quantity of sewage and the quality of sewage in one town is entirely different from the quantity and quality of the sewage in another town; it is totally different, varying with different conditions, such as the trade operations that are being carried on there. I want to show that there is a difference from that fact alone. That is a difficulty, and when we hear a man saying that this is the system of treatment or that is the system of treatment, we must remember that the sewage of different towns differs altogether. There is something else, because, secondly, I say that the sewage of some towns varies at different times of the day, and under different conditions of weather. It is no good your going down to a town at a particular time and taking a sample, and saying, "This is a sample of the sewage of the town." As a matter of fact, it is not a sample of the sewage of the town; it is only a sample of the sewage of the town which has been collected at the outfall at a particular time, and nothing else; and I think it is important, therefore, on this question of the treatment of sewage, that we should distinctly bear that fact in mind. As I say, the sewage of one town is not at all the same as the sewage of another, and the sewage of the same town even varies at different times.

Now, I am not going to discuss here any question of the advantage or otherwise of the separate system. I do not want to enter into it to-night, though I have discussed it fully in the paper I have prepared. I have no doubt of this, that for the purposes of irrigation separation is an advantage. For the purpose of precipitation, dilution, within certain limits, is not an evil, and we must remember that the question of the separate system must bring before us the question of what you are going to do with the sewage—what sort of system you are going to adopt for the purpose of getting rid of it. We must remember this, a steady uniformity of views is, no doubt, a very good thing, but a steady uniformity of views is not everything. Steady uniformity is at times a perfect nuisance; in fact, there is a great evil in having steady uniformity in everything, and especially in sewage matters. You lose the advantages in this case of a good flushing; and I do not know anything that is a greater loss than that. It is very easy to be very clever on the separate system, but I venture to say that the separate system would mean an intermittent pollution of all the water-courses of the country. There cannot be a shadow of a doubt that the foulest sewage is brought down in the first hour's rain from the washings of the streets and such like. I am afraid that, in these days, we are getting to be too much phrase worshippers. We all know the phrase about the "Rainfall to the river and the sewage to the soil." It is very pretty, but it is not correct. It is all very well throwing this phrase at you, using it as an argument, but it is no argument at all.

Well, I come now to the composition of the sewage. I am sorry to say I cannot give it you exactly. You cannot tell what is the composition of sewage. It varies in a number of different ways. Suppose, for instance, I take the average of an enormous number of sewages, and say we get about 45 grains in solution and about 44 grains in suspension, I should not be very far out; but at the same time that is not a very satisfactory statement after all, because the composition of sewage differs at every hour in the day. There are weak sewages and strong sewages, average sewages and non-average sewages. We have all sorts of sewages. The term "composition of sewage" is, therefore, simply nonsense. We cannot speak of average compositions unless you take samples of the sewage every half-hour, and then mix all the samples together, and make an analysis of the mixture of the half-hour samples during the twenty-four hours. That gives you an idea of it. But the idea of going and taking a sample merely, and saying that is a real example of the sewage of a town, is nonsense. Well then, the great thing of course to be done was to get rid of the sewage; and, the water-carriage system was introduced in order to wash it away from your houses. But, then, the next point was how to get it away from you, how to get rid of it as soon as possible; and of course the easiest way to do that was thought to be to send it into your rivers. All I can say is, that letting it go into your rivers means, for the most part, putting off the nuisance from yourselves to your neighbours. Of course it is a very easy way of doing it, but the great evil of letting your sewage go into your rivers is from the suspended matters which you have in your sewage. I do not think the other part of it makes much difference. The matters in solution do not make much difference if they are well mixed, because they soon got oxydised. Everyone believes that, I think, except one or two individuals, now-a-days, and I will say no more upon it. Then with regard to the solid matters, we generally find that the solid matter flows about the outfall; but some of the matters in solution combine with the aluminous constituents from alluvial soil, and so forth, and became insoluble, and then we get a curious sort of suspended matter. We find, for instance, the manurial matters going down first, and then, as the mixture of sewage and water flows on all the organic matters, of varying density, go down. Of course those that are lightest or most flocculent of all go down last, and very often that is the most offensive of all kinds of organic matter; so that when you let your sewage matter go into your rivers, you do not, perhaps, get much nuisance near you, because, of course, the organic matter has gone down lower. The organic matter sinks to the bottom of the water, and there undergoes putrefactive decomposition, until after a short time the gases developed are sufficient to render this material specifically lighter than the water; then it comes up, gives off its gases, becomes heavier, goes down again to putrefy once more, with other matters added to it, then comes up again, and gives off other gases. That is the history of suspended matter introduced into the river in that way.

Well, it was quite clear that would not do. People could not stand that sort of thing, and so they set to work to see what they could do with their sewage in some other way. Two things could be done with it; but let me put one first. It was absolutely necessary that one thing should be done with it; that is to say, that it should be purified, that was certain. And the second thing was that, inasmuch as the sewage had a certain manurial value, it was desirable to utilise whatever valuable constituents were present in it. Those were the two conditions required. First, to get what you could out of it, and next, to make it as pure as possible. But there was something else. Of course you must purify it, or else there would be litigation, and therefore you must do that, and you ought also to do your best to get all you could out of it; but whatever you did with it, you must do it without causing a nuisance. Those were the conditions, that you must purify it, and that you must get what you could out of it; but you must do both without committing a nuisance.

Now comes the question of the value of sewage. It is wonderful how people talk, or rather how they used to talk—they do not talk quite so much about the value of sewage now. The basis of the calculation is simplicity itself. There can be no doubt we can easily calculate the value of sewage. Dr. Corfield does it in his book with the greatest ease in the world; you get your population, you find the quantity of the excreta, you find out the constituents and the relation of one to the other, and there is your calculation. Well, it was very curious that a calculation so simple as that should have brought forward a heap of authorities who differed very widely as to what the value of the sewage was. I have just been looking through the evidence which was given before the Select Committee of the House of Commons in 1862, and there the authorities differed between halfpenny and 9d. a ton. It was very curious, seeing the simplicity of this little calculation, that they should differ so much as that. They said there was nothing easier than to calculate the value of your sewage, and yet they differed so widely as that—between a halfpenny and 9d. The interest, of course, of this whole matter is centered in the value of the sewage of London; and I have been trying to get together the views of all the people who have views on the subject, for the purpose of seeing what I can make of it. There is a class, which I will call the cautious people, who, taking the population as 3,000,000, estimated the value at 6s. 8d. per head, and they calculated the value of the sewage of London as £1,000,000 a year. Then there was another class of less cautious people, Mr. Brady and Lord Robert Montagu I will put amongst them, who thought that to take 6s. 8d. was nonsense, and they made out the value of the sewage of London as £2,890,000. Then there was a class of very heroic people, as I will call them, numbering amongst them eminent chemists, and they calculated the value of the sewage of London as £4,081,430. Those are the different opinions which have been given about the value of the sewage of London. When you asked them about it, they said, "Our calculations are based on the teaching of science." I am carefully using their own words, that they were "based on the teaching of science." Well, of course, if this sewage is of this extraordinary value, we must try and get something out of it to help to pay the rates, and people said—let us apply it to London. That naturally resulted. Enthusiasts fully believed in its value, and arithmeticians and scientific men were found to start sewage farms. I see before me a very distinguished man, who I think was one of the earliest of those who tried the plan, but a certain unpleasant awakening occurred with regard to all this. Science told its story, and through the mouths of its authorities, some of whom I see before me, told that story well. They told us how the land acted,—how it was a mechanical filter, and a chemical laboratory at the same moment; how as a mechanical filter it took out the solid matter; how as a chemical laboratory it effected the oxidation of the nitrogen which the plants took up and utilised, and brought back again for our use as food. They told us how the churchyard feeds the village sheep; how the sheep feed the villagers, and how the villagers feed the churchyard herbage. They were always telling stories of this kind. Science talked in this way, but then the farmers had something to say about it. They said, "All that is true, no doubt; your learned societies say so, and, therefore, it must be true."

Still, the farmers had their own views on the subject, and their views led to this conclusion, that they would only take the sewage at such times as they liked, and in such quantities as they required. What is the result? Some great and learned people thought the farmer very foolish, very ignorant, and very obstinate. I do not think I am putting that too high. They traced the obstinacy of the farmer to his conservatism—I mean his blind attachment to old-fashioned ways, good and bad. The facts did not support this view, still they stuck to the fact that the folly of the farmer was his conservatism. Well, the farmer does not quite follow this conservatism in everything; he shows his appreciation of newly invented manures; he thoroughly understands the value of superphosphate. He is not conservative in that. He is not conservative in adopting new agricultural implements; he does not show any blind attachment to old fashioned ways there, but he did in this matter of sewage. Mr. Chadwick preached with the authority of a Board of Health at his back. I will quote his own words, so that there shall be no mistake about it:—"That liquid manure was at all times preferable to solid manure, and suitable for all crops, and all soils;" but Mr. Chadwick's sermon fell upon bad ground. Mr. Chadwick piped, and the farmers refused to dance. Seeing that this part of the subject was a failure, gentlemen farmers set to work. They set to work for the purpose of teaching the farmers, but after a while even the gentlemen farmers gave it up. They learnt a lesson at some cost, and left off their work, sadder, wiser, and poorer men. Mr. Chadwick still preached, but the people began to suspect one of two things. either that there was some obstacle to the agricultural use of sewage, or that its theoretical was not its practical value. Local authorities too found this, that if they had to apply sewage to land in order to purify their sewage they must secure the land, they could not trust to the farmers taking it. Why? Now comes the part of my story that is important. Why did they require land? First, that the sewage might be taken at all times, day and night, Sundays and week-days, all the year round, summer and winter, whether the soil wants it or not, whether there are any crops or not, and at all stages of their growth, seed time and harvest. The farmers did not see the force of that. Secondly, they found out that it was necessary so to purify the sewage as to produce an effluent which, under every consideration, should not produce a nuisance, nor pollute a watercourse. The farmer looked after his crops; the local authorities looked after their effluent, and the two things did not agree. The farmer said, "I admit a certain manurial value; I am not going to dispute that science teaches it; I should not care to discuss the question with science; but on the whole, having given the subject my consideration, I prefer to sacrifice the manurial value rather than be compelled always to have the water." That was the conclusion of the farmer.

Besides, he says, "it is no use your pointing to other countries, and telling me what a wonderful thing irrigation is in India, and in Continental places, and so on, that will not do; temperature is against us here; wet weather is against us; look at frost" (and I shall say something about that before long); "allow your ground to remain quiet and aerate it, which was necessary, and the ground freezes; neglect to aerate it, and it is no good." That is the first great difficulty. It is no good telling me about the increased temperature of sewage, and I shall have something to say about that before long. Frost, rain, and storm, water-logged land — the very time when you have the most sewage to deal with, the ground is in the worst condition to take it. Hot weather cracks your clay, if you have clay, and down goes the sewage without being purified at all.

Dr. Carpenter, who is an ardent irrigationist, has pointed out the difficulty of management, and there are some remarkable passages in Dr. Carpenter's paper, when he was, perhaps, forgetting himself a little on that point. Increased cost—the Local Government Board know something about that in their report. Then we come to this curious fact, that you cannot get one single point upon which these ardent authorities are agreed. I have been trying to see if we can get a starting point on which they are agreed. They do not agree upon the method of application—whether it shall be by hose and jet or not. "The soil best suited is very porous soil," said Professor Way — and he knows a good deal about it; "a heavy soil" says Liebig—and he knows a good deal about it; and then others go between the two. Then some say that the crop most suited is rye-grass, and I think they are right. Others hold different opinions.

Now comes a crucial question—How much sewage *qua* agricultural success, can properly and, *qua* sanitary success, safely, be applied to a given area of land? Now I will ask you for a few minutes to regard this question of area before 1870 and after 1870, and, I was almost going to add, after April 14th, 1886; but I will take it, if you please, before 1870. The agricultural and the sanitary aspects of the subject were not in accord. To realise your agricultural success you must apply a large quantity of sewage to your land, and that you know they did. Realise your sanitary success, and then the rule is apply a smaller quantity, the smaller the better. So you have for agricultural success to get as much as possible out of sewage; and for sanitary success, in order to purify it to have as little as possible. Can you split the difference? The authorities differ between 2 and 800 as to per-centage. Mr. Mechi said 2, but he altered his views afterwards; Mr. Hope said 20 or 30; Mr. Way and Sir Robert Rawlinson 100 consistently; and I think I shall not be unfair if I state it thus, that the authorities on the subject all say (and recollect I am speaking of before 1870) that 100 is the minimum to pay, and then a great many other persons said that 30 was the maximum to escape prosecution.

Our friend Dr. Frankland saw that difficulty. He saw what I will call the land difficulty; he saw this, that the greater the quantity of sewage that you have the more land you required, and the less land there was to have. For a very large town there was very little land in its neighbourhood. A small town had plenty of land, but there was very little sewage. Not only did you require more land where you had more sewage, but the higher was its price. Dr. Frankland grasped that difficulty, and he said to himself, I have no doubt irrigation is doomed, unless I can find out some method of concentrating a large volume of sewage on a small area of land. Well, Dr. Frankland in this, as he has done in a good many other difficulties, saw a way of escape. In the year 1870, Dr. Frankland set to work to make a series of laboratory experiments. He took a cube foot of earth, and calculated the amount of sewage that that cube foot of earth in his laboratory would purify. I am very particular about this, because a certain letter in the *Times* of to-day, about which I shall have something to say hereafter, necessitates my drawing attention to this. I am sorry Dr. Frankland is not present to hear the criticism which I have to offer; but I know he is some distance off, and therefore cannot get here. A cube foot he makes the experiments upon—and wonderful experiments they were. These laboratory experiments gave birth to a system called intermittent downward filtration. Just let us see the conditions, and I will represent things as fairly as I possibly can. First, he says, you must have "suitably constituted soil." I am using his own words. It is difficult exactly to say what he means by "a suitably constituted soil," but I suppose I shall not be far wrong in saying that he means a soil not too open, so that anything may pass, and not too close, so that nothing will pass. Then he says (and let us be clear about this) as the essential part of intermittent downward filtration you must have deep draining, and that is fixed at 6 feet. I am using his own words, because his calculations are made upon 6 cubic feet, so as to allow a considerable distance for percolation. So that, if one foot will do so much work, six times that number will do so much more. This is Dr. Frankland's principle of filtration as opposed to irrigation, but it is intermittent. Dr. Frankland says there is something like a lung action—a constant taking in and giving out; he says he copies Nature. Dr. Frankland makes his experiment on this cube foot of earth, and inasmuch as this cube foot would do so much work, he calculates what six cubic feet would do, one on the top of the other, and he calculates 3,300 persons to the acre. He says I have got a new intermittent downward filtration, and I can put a large bulk of sewage on a small plot of land. Now, let me illustrate this with a case. I am going to try to give you an account of what, I suppose, is the intermittent downward filtration. Suppose I had a population of 9,900 on three acres; subdivide each acre, as he says, into four parts; put on each of those four parts your sewage of 3,300 for six hours; take it off, put it on another part, that gives 18 hours' rest to each part of your acre. That is the intermittent system. Of course there were people who went far beyond Dr. Frankland. We had a further development suggested. I fancy it was suggested that of those three acres the one should be used one year, and that the sewage of the 9,900 people should go upon that for that time, while the others rested. That might very fairly and properly be called intensified intermittent irrigation. I do not think I am using a wrong phrase. Let us not in any way misunderstand Dr. Frankland. I am not saying a word against him, because as a matter of fact no one knows the subject better than Dr. Frankland. But of this intermittent downward filtration, Dr. Frankland said that it involved the sacrifice of agricultural property. It is fair that we should be distinct about that; he always said it involved that sacrifice. I refer to that because some of his followers take a different view; my friend, Mr. Bailey Denton, does; I know he thinks otherwise. He thinks that intermittent downward filtration is the best way of getting a good crop.

Now, I want to consider a new aspect of this case; the sewage without the removal of the sludge (because this is the principle of Dr. Frankland) is put upon the ground. But two insuperable difficulties occur, and I am now speaking of the results of my own experience on this subject. The first is that, as the result of this application of sewage to land, you destroy your land as a filtering agent; that it is not, at the end of a year or two, what it was when you commenced; and, secondly, that it is almost certain that you have a nuisance. I am going to take these two points, and enlarge upon them. First of all, then, I would note that Mr. Bailey Denton (and he knows this subject exceedingly well) contends that when you put that sewage with the organic matter in it upon the land, and dig it in, as he says you ought to do—it undergoes decomposition—renders the ground lighter and better by increasing its filtering capacity. That is Mr. Bailey Denton's contention. From that statement I absolutely and entirely differ. Now, just let us consider it. The sewage is applied, with the matters in suspension, to the ground. For 18 hours you apply none. The fact is that you get over a certain surface of your ground a covering which is practically impermeable, and which is not removed at once when the sewage is again applied to the land. It is curious what it is. There is first of all a considerable quantity of albuminous matter, but it is something else. We know the immense quantity of paper that goes into the sewage; now all this disappears. That is a remarkable fact; but what becomes of it—it gets beaten up into a kind of *papier maché* in the sewage; and it is that *papier maché* I think which clogs the ground; you dig it in; it simply fills up the pores with a glutinous and *papier maché* cement, and you may put any amount of sewage on you like, but it will not go through. I know that to be true, for I have tested the subject with every possible care as to the relative power of earth for allowing sewage to go through after its application. It clogs the land; your land deteriorates. Now comes the 3,300 per acre. I suppose there was no greater authority than Mr. Bailey Denton on intermittent downward filtration. When he had to treat the sewage of a population of 13,500 at Kendal, he suggested 16 acres of land for the process; but the authorities did not see this, they had the report of the committee before them, and they said 3,300 to the acre. They were very liberal to him, and suggested 5½ acres, but it did not answer. I must say, I do not like to enter upon this now, but the letter of Dr. Frankland in to-day's *Times* has rather astonished me; he has come down, at any rate, to 2,000 to the acre; but I want to show what an extraordinary result we have got. Dr. Frankland's results were based on this—a cube foot of earth would purify a certain quantity of sewage, and, therefore, six cubic feet, one under the other, should purify six times the quantity. He tells us here that this conclusion is drawn from the Warrington experiment, and that, inasmuch as it proved that the purifying action only takes place near the surface of the land, it is only necessary to drain the soil something like 2 ft. deep instead of 6 ft.; but where have his own experiments gone? His own experiments were based upon the cube foot of earth; the power it possessed to purify a certain quantity of water multiplied by a certain number, but now he has abandoned it. Dr. Frankland's letter has rather put me out. I do not know where we are.

I cannot help coming to the hygienic aspect of the subject, because it has a medical aspect too. First of all, we cannot hide from ourselves the nuisance from offensive emanations on the ground; we have seen it over and over again. The evidence is abundant. Can it be otherwise? Injurious matter on to the ground, the water allowed to drain, and its material kept upon the surface, evaporation occurring; evaporation means the carrying, not simply of water in the air, but a considerable quantity of solid matter, that is carried off during the time of evaporation. For instance, you go into a room newly painted, and you get lead poisoning. How? It is not due to the volatilisation of the lead, but the turpentine, in the act of evaporating, carries solid lead into the air. That is the explanation of the lead poisoning; when the smell has gone the danger has passed. What do you do here? You have a thing which of all others you want to keep out of the air, and you spread it over a large surface of ground. I will not enter into another aspect of the question, which, from a medical point of view is immensely important—I mean the saturation of a district with moisture. This would not be the place to enter upon it, but I may say the masterly research of Dr. Buchanan has clearly shown the danger of that.

Then we have pollution of subsoil water; we have the distribution of undefecated sewage, containing the ova of entozoa and other things which I might mention. That is irrigation. I want to be very careful about what I am saying. I do not for one single moment mean to say that there are not cases where irrigation should not be properly used. When I come to discuss, as I hope I shall before I have done, the question of how you are to treat your sewage, I shall emphatically say you cannot treat it this way or that, but you can treat it in various ways at different places, and irrigation may be one of them; I am only saying that irrigation is not the way to meet it universally—it cannot be.

Now let us review our facts. We have dilute sewage to deal with; we desire to be sanitarians, to purify our sewage, so that it shall not pollute our watercourses, and in purifying it not to cause a nuisance. We desire to be economists, viz., to get from the sewage all that is valuable in it—in a word, to achieve by one and the same operation a sanitary success and a commercial profit. In sewage, as in other things, you cannot combine the incompatible. To achieve your commercial success, you must abandon sanitary considerations, and you must, as at Edinburgh, flood your land with 10,000 tons per acre per annum, until your farm is a stinking morass and your effluent water so impure that you must take it directly into the sea lest it foul your watercourse. Achieve your sanitary success, sprinkle your 300 tons on your acre with hose and jet, and away goes agricultural profit.

Try a compromise between the extremes of 300 and 10,000, and the chances are you get the difficulties of both and the advantages of neither. I admit possible exceptions. Do not misunderstand me. I say again I admit possible exceptions. A small population, cheap land removed from human habitations, a porous soil admitting free percolation, good gradients not requiring steam power, proximity to the sea, so that extreme purity of effluent is not demanded, and proximity to a town, so that a ready sale for the rank sewage grass for dairy purposes could be secured. But the difficulties are enormous. I must have enough land, and the greater the population the greater the quantity of land required, and the larger its price. I must have proper land, sufficiently porous, but not too porous. I must have land properly levelled and properly drained. If the level of my drain be above the sewer out-fall, I require costly motive power. The larger the quantity of sewage, as in wet weather, the less able is the already overcrowded land to deal with it. Frost or snow, the work has still to be done. At all times the effluent must be sufficiently pure, lest litigants be aroused. At all times the operation must be conducted without offensive effluvia from an over-sodden state of soil, and without polluting the air by rendering it abnormally damp or affected by sewage effluvia. Without polluting the air I say, for that means typhoid. The subsoil water must be so diverted that neighbouring wells shall not be polluted. Grant all these difficulties overcome, and there remains in the produce of my farm a grass unfit for dairy purposes, and likely to be a source of entozoic infection to men.

Now I come to precipitation. Let us understand what precipitation is:—The addition of certain chemicals whereby the deposit of the solids in suspension, and some of the dissolved matters is effected, together with the deodorisation of the offensive constituents. I have taken the trouble to go through, so far as I can make out, nearly all the patents which have been suggested for the purpose of precipitation, and dry work it has been. I have endeavoured to find out where they have been used; and I have got information from the different places as to the results. I think you may say this, that those agents principally employed are practically lime, salts of magnesium, salts of alumina, salts of iron, alone, or mixed up one with the other, in all sorts of proportions; whilst in addition some people put a certain amount of weighting matter to carry the precipitate down, and others an absorbent matter to absorb the gases. I want to put it that there are, to my mind, five conditions as to a proper precipitant; first, that consistent with purity, the chemicals used should be cheap. Secondly, that the precipitants should act as deodorisers and disinfectants. Thirdly, that the maximum purity should be obtained with the minimum of deposit, that is in the smallest possible quantity of chemicals. Fourthly, that the precipitated matters should subside rapidly. Fifthly, that the sludge should part with its water rapidly. I think these are the five conditions of success so far as precipitants are concerned. I have here some tanks which have been kindly sent to me by the A B C Company. In one we have the crude sewage and in the other the effluent, and I will ask Mr. Page to add some of the A B C material to the sewage in one of these tanks, in order that we may see how the precipitating action goes on; but I wish it to be understood that I am not here to advocate this or any system. The A B C system, I will say at once, produces in my own experience, and in that of Professor Dewar, who was conjoined with me in a research on the subject, a very good effluent. I am not going to say any more than that. Those who have had an opportunity of investigating the subject will admit that it does produce a very good effluent; that is all I say.

Now, I come to the practical question, the question asked, I would say, all over the country, and the question asked of those who have to advise on these matters, in tones almost of painful despair. How shall we deal with our sewage? I want to say this, there is no one single answer to be given to that question. The adviser must, if he wishes to do justice, sink his hobby. I do not care whether it is the hobby of precipitation or the hobby of irrigation — he must sink his hobby. He must be prepared to find conditions under which he would advise irrigation, and conditions under which he would advise precipitation. And let me say he is certain to find (in my own experience they are to be found) conditions that are favourable to one hobby at one place, but are absolutely inconsistent to that hobby at another. I want to say this, too, that it is no good people holding up success at one place as an argument that that process will be successful everywhere. It is no good to have sewage works at A, and to take people from B, C, and D down to those works at A to see how successful they are. That will not do. We have to consider the place, and we must be prepared to adopt any process that is the best fitted for that place.

Let us consider one or two general points. I am going to quote the words of my friend Sir Robert Rawlinson, "towns must be prepared to pay to be clean." That is what he said once in this place. You must purify your sewage at the expense of the rates.

[Sir Robert Rawlinson took exception to the expression "purify." "Clarify" was the proper word.]

I do not argue about the word; towns, at any rate, must pay to be clean. Secondly, and I think Sir Robert Rawlinson will agree with me in this—I know I am on tender ground with him—the sewage must be got rid of—I am sure he will let me use my word, purified — at any cost. Minimise the cost he would say, but you must do it at a cost; and there must be an annual expenditure. Thirdly, and I think we shall agree here, that the sewage requires constant attention; you cannot be attending to it one month and leaving it the next—you must be always at it.

I would say this, it is not simply applying to the Local Government Board, and having an inspector to go down and see whether he will grant borrowing powers for certain works. That is all right enough, Local Boards do not mind doing these things sometimes; but Sir Robert Rawlinson will tell you, I am sure, that there is something else wanted. It is not the borrowing of ten, twenty, or forty thousand pounds, but it is the yearly expenditure to keep up those works that is necessary. Fourthly, to allow your sewage to go into a river means passing your filth on to your neighbour. The sewage ought to be treated, in my opinion, where it is produced. Litigation is, in my experience — although I may have derived advantages from it— a more expensive luxury than sewage treatment, and on the whole I think it breeds far more ill-will. Fifthly—I think Sir Robert Rawlinson will go with me here—that in treating our sewage we do not want a drinking water, and we do not want a Peruvian guano. Now, we go to a town, and the sewage has to be treated. We ask how much is there to treat, and what sort of stuff is it?—that is to say, what are the manufactures, and so forth. Our very first thought necessarily is, and it would be my thought first—irrigation. The local authorities must get land. It is no use talking about farmers; you must get land. To get land is a very difficult thing; and when you get land, you have to pay a fancy price for it generally, especially if it is for sewage. And there is something else about it; that all the people who have land in the neighbourhood of your proposed sewage farm suddenly discover that all their land is building land. Now come certain questions. Is it practicable? And I think I may put it thus. There are three questions we ask ourselves, supposing we think about irrigation. Is it practicable to obtain sufficient and properly situated land for the purpose; sufficient —I am not going to define that now; properly situated as regards general character, level, and so forth. Secondly, is this properly situated land reasonably near to the town, so that the cost of conducting the sewage shall not be excessive; reasonably distant, so that the town may not derive injury from a nuisance likely to cause disorders. And then, thirdly, is the land of such level that the sewage can readily reach it? There is a fourth question, Where is the effluent to be discharged?—and I beg to submit that this is a very important question in any irrigation scheme. You are dependent for effective purification on effective land in effective order. But land becomes ineffective from circumstances over which you have no control. First, for instance, frost; second, in times of heavy rain, land is water-logged, and when there is most sewage to be treated, your land is least able to treat it. If, then, the outfall be into a river where considerable purity is required, and not only purity, but unfailing continuity of purity, then it appears to me that an irrigation scheme must be regarded as an unsafe scheme. But where there is a discharge of an effluent, or the discharge of a little doubtful water at times, or a little doubtful sewage, that is a matter of secondary importance, and it appears to me your irrigation scheme may pass.

My own experience of all kinds of schemes (and I think I have seen most) has led me to prefer by a very long way indeed a combination of a precipitation and an irrigation scheme; and I see for it two great advantages. First, its efficient working is independent of weather; second, if you have sufficiently large works, any emergency of quantity can be met. I am bound to say this, looking over the papers of people who have written on this subject of precipitation—and precipitation has its greatest and heaviest enemies in its advocates—one is perfectly astounded at the extravagant advantages which have been claimed for precipitation. The sludge has been advertised, and is advertised, as of enormous manurial value. Patents by the hundred have been taken out. Precipitation advocates have invariably been the advocates of a system, and no wonder the public began to doubt everybody and everything. They have taken the claims advanced by the precipitationists, and they have weighed them in the balance of facts, and they have found them wanting. I think you will believe, after that statement, that I am not here as the advocate of a system. I said the A B C turned out a good effluent, and so it does. My own experience leads me to speak very highly indeed of the use of lime, and sulphate of alumina. Put in your lime first. Your lime does three things—it produces carbonate of lime, acts as a weighty material; some of the lime is combined with some of the organic matter in solution, something like a quarter or a fifth of it, into an indescribable chemical compound. The rest goes to make the water alkaline. Then add the sulphate of alumina; the alumina sets free the ammonia, which combines with the sulphur; it acts as a mordant, and down it goes. That is not a patent. Now, I am bound to say this—I have never yet seen an effluent from a precipitation process that has not a slight smell about it; but it is not the smell of sewage, it is the smell of effluent, *sui generis*. Now, let that effluent, after precipitation, flow over a small area of land, and you give your effluent the final finishing touches towards purification. Just think of it from three points of view. You cannot cause a nuisance in that act because you get no suspended matter, and you get nothing on the surface that will decompose and give off offensive matters. You cannot clog your ground, because the materials that were in solution are precipitated. Thirdly—I attach no importance to this, because I do not think anything of it; there is a certain manurial value. The quantity that it takes varies with the land—about 5,000 to 10,000 per acre will do Such sewage works are no nuisance. Your process is carried out in wells, your tanks are little more than ordinary pure water tanks, with no more smell; and your sewage, when it gets on the land, has no smell either.

This subject of precipitation has occupied me a very great deal, and I venture to put forward five points to which I wish to draw your attention. First, if you want to treat sewage properly by a precipitation process, you must treat it fresh. I am not going to define what "fresh" means, but I mean before active putrefaction sets in; it may be twenty-four hours or it may be forty-eight hours; it varies with the time of year, or with the chemicals that are allowed to go in from various manufactories. Of course one change has probably occurred, and that is the breaking up of the urea. I do not know anything more wonderful than the absolute disappearance of urea; by the time the sewage reaches the works an enormous quantity must be broken up. Then there are all these different decompositions, and you must deal with it before the first active change occurs. As a matter of fact, fresh sewage has very little smell at all. Then, secondly, I think it advisable, as a rule, before you mix your chemicals with it, in order to minimise your chemicals, that you should strain your sewage in some way or other. You cannot strain it entirely, but Mr. Baldwin Latham's apparatus seems to work exceedingly well. I have seen it working, and some method of that kind should be adopted. Then, thirdly, you should add sufficient chemicals to effectually complete purification. It is a great mistake to starve your chemicals. I know as a fact that local authorities will spend money on works, but when it comes to actual working year by year, and day by day, then it is they fall through. My friend, Sir Robert Rawlinson, knows that is the test; it is not the borrowing of £40,000, it is spending £800 or £900 a year in doing the work after they have got the works.

I do not like to enter on this subject of sufficient chemicals, especially in view of a report I have here. I have very strong views about it; but will not enter upon them now. I will only say this, that I am astonished that, when I proposed in a certain scheme five grains of lime and five grains of aluminum, one of the gentlemen who signed this report showed to a certain inspector how absolutely useless it was to add that quantity of chemicals to sewage, and said it would lead to no result at all. I say nothing about that for the present, though I may have something to say on another occasion and in another place. I want simply to say, with respect to these chemicals, that my strong conviction is that the quantity ought to be calculated on the population and not on the sewage. I have always felt that most strongly. Then fourthly, it is very important that there should be efficient stirring after the addition of the chemicals. You may add your chemicals, and it will produce no effect; give it a good stirring up; we chemists know the value of a stirring rod. Then, fifth, it is essential that you should have sufficient tank accommodation. I have worked that out as far as I possibly can—sufficient tank accommodation—for two reasons: 1st, that the precipitate should subside perfectly, that is important for the flocculent matter to go down; and secondly, that the sludge may be frequently removed. It is important that the sludge should be frequently removed from the tanks for two reasons. First, if you allow the old sludge to remain in the tanks, it is perfectly certain that it will contaminate your fresh sewage after it is treated, when it comes in; and you must have it sufficiently large, or the sludge at the bottom will undergo decomposition, and render the sewage impure after you have treated it; and, secondly, that when removed you may not get any smell—that is to say, that it may be done sufficiently frequently. Another thing which is very important is this, that when the sludge is taken out of the tank, the tank itself must be washed. It is those bits that get left in which cause so much nuisance. There is nothing like cleanliness in the treatment of sewage.

In these circumstances, the question arises, Have you produced such an effluent as will not pollute your water-courses or prove dangerous if discharged into a river used for drinking. I say that by combining precipitation, which will produce a good effluent with land treatment, or prepared filters, or something of that kind, you may produce the best effluent that is known. The late Royal Commission—Lord Bramwell's Commission—in a very able report, dealt with that, and stated that as their conclusion. I am not saying whether I agree with the report so far as London sewage is concerned, but as to that being the best method of dealing with sewage as an abstract question, I do agree with it.

Then, secondly, comes the question, is not the sludge an inevitable cause of nuisance? It was formerly. I am not certain that the materials in suspension were not a greater nuisance when taken out of the sewage than when left in it, I sometimes used to think they were. I will not discuss now the quantity of sludge, but I would say as a general principle, consistently with efficiency, produce as little sludge as possible; first, because if it has any value, you secure its maximum value, and, secondly, if it has no value you have the less to get rid of.

Now, I will say a few words on the disposal of sludge; and it is almost my last point. A great change has been wrought lately by the introduction of Mr. Johnson's press. It has almost revolutionised the question of precipitation; to my mind it has quite done so. This sludge was always our bugbear—we never knew what to do with it. The principle of Mr. Johnson's press is this. You have a series of compartments in which there are canvas bags; the sewage is compressed into these compartment by means of air pressure, about 120 lbs. to the square inch, and then the material is thoroughly pressed in these presses, the liquid is pressed out, and the solid part remains in the compartments as a solid cake, of which I have a large specimen here. It is perfectly compact, very easy to handle, and has not very much smell. I do not say it has none, but not very much. The water is reduced from 90 per cent. to about 50 per cent., and I should like to draw attention to the fact that the liquid which is expressed from this sludge—and they generally put in a certain amount of lime, which renders it more easy of pressure—is of a very foul nature. This was a matter investigated by Professor Dewar; we worked at it some time in common, and we found it was very unadvisable ever to return the liquid from the sludge press into the ordinary sewer, which was formerly the plan. It cannot be re-treated in the ordinary way; it requires a different kind of treatment, by chloride of lime, and some other things which I will not refer to now. It must not go back into the sewer, but must be treated by itself. I am quite clear on that point, and it can easily be done. It renders the sewage into which it is returned somewhat difficult to treat, besides being itself not treated. I have considered in some detail the value of this sludge, and the cost of dressing it, and I may say the dressing costs from 2s. to 2s. 6d. per ton. That, I believe, is a wonderfully practical method of doing it. I have walked about in the middle of thousands of tons of this stuff, and really smelt it very little. My own opinion is that Johnson has done a very great deal to change the precipitation works from being a great nuisance into being comparatively no nuisance at all.

It would not be fair in this room to pass over General Scott's process, which was very ingenious. His process was to take the sludge, which was precipitated with lime in this case, drain it, and then dry it by heat, and burn it in kilns, grind the clinkers, and use it as a hydraulic cement. And I believe General Scott said that the cement thus prepared was worth something like 35s. a ton. I cannot help thinking that may be all very true up to a certain point, but at the same time it is very evident that the sewage varies in different towns enormously, and that it would be difficult to get a cement of a constant character; and it is a very important thing, so far as I understand engineering work, that cement should be of a very constant character.

Then, thirdly, there is the destructor, and, to my mind, the destructor has reached its highest state of perfection at Ealing, from the great thought that Mr. Jones, the surveyor of Ealing, has given to it. His sludge there is mixed with house refuse and burnt. Mr. Jones's view is that every town produces sufficient house refuse to burn the sludge. One has to notice the differences of destructors. I have seen a good many myself, and I should say the differences are mainly two; first, a certain escape of offensive vapours from the shaft, and I think those offensive vapours are mainly due to partial burning—the destructive distillation, as a matter of fact, of the materials, instead of their complete destruction; secondly, the escape of fine sand and such like from the shaft at certain stages of the operation. I have seen those two nuisances very well marked, and I had occasion to advise on them on more than one occasion. I cannot help thinking myself that in Jones's destructor, where he places a muffle furnace or "fume destroyer," as he calls it, between the furnace and the main shaft, he has, in a great measure, met those two difficulties. I think, myself, that Jones's destructor is a very creditable thing.

I feel rather a difficulty in saying a word on the subject of standards, and yet I do not know that one can altogether omit it. I can only say that Professor Dewar and myself found out the absurdity of comparing a sample of raw sewage with a sample of effluent. People go to a sewage works, and take a sample of sewage and a sample of effluent and compare them, which is of course manifestly nonsense. You can only compare them by taking say, half-hourly samples of effluent and half-hourly samples of sewage, mixing them all together and comparing the average. You cannot compare a sample of sewage with a sample of effluent, for this reason. Say they are both taken at twelve o'clock. The twelve o'clock sewage, say, is strong sewage, but the twelve o'clock effluent probably is the effluent of the six o'clock sewage, when it is at the weakest; so that you are comparing the effluent of a very weak sewage with very strong sewage, or it may be the opposite. You cannot compare one sample with one sample taken at the same time, or compare them in any way except by taking averages. Of course, it is very important in taking samples by which you are to come to any conclusion that you should know the weather, the average flow, and so forth. Now one word on what may be called a practical standard. We always hear about standards, and they are not very satisfactory. We had the Rivers Purification Bill, which I am very glad to say the House of Commons in its wisdom turned out. That was a very great point, because it was a very bad Bill, altogether bad both in principle and in theory. We want a Bill, however, to keep sewage out of rivers, and we ought to have it. We must leave the manufacturers alone for the present. It is quite hard enough in our days for people to get a living, and we must not be interfering too much with trade. I do not mean to say that will not come, I think it will; but we cannot do everything at once, But I will tell you what we can do. We know sufficient about sewage now; the Local Government Board has taught us a good deal, doubtless. At any rate, we do know enough about it to know that we can purify it, or clarify it, up to a certain point. And I think we ought to keep our sewage out of our rivers, and it is the duty of the local authority to do it. But we cannot be having elaborate chemical tests. Let us have some common sense standard. Something of this sort I may throw out as a suggestion. First, that your effluent shall be clear and colourless when seen in a white pint cylindrical bottle. Secondly, that it should not be alkaline to test paper—you can get that, and an alkaline effluent is not a good effluent. Thirdly, that on the addition of a grain of sulphate of alumina, or say, one grain of alum, dissolved in 100 grains of water, added to the pint bottle, it shall not produce appreciable turbidity after standing thirty minutes—you can get that. Fourthly, that if you take that white cylindrical bottle half filled with sewage, and shake it up, it shall not leave foam or much froth after standing ten minutes. These are practical tests.

I do hope the day is not so far off when we shall have some means by which we can persuade local authorities to purify and deal with their sewage. But I say again that if we are to do it, we must not act as the creators of a hobby, we must be prepared to sink the hobby; we must not go as violent irrigationists, because it is clear that that will not do; we must not go as violent precipitationists, it is clear that will not do. We must be prepared to consider what is the best method to treat the sewage of the place for which we are called upon to advise.

I cannot help feeling strongly on one other subject. I know we cannot alter it; we have this water-carried sewage to deal with; but one cannot help asking the question, if one were called upon to advise for another London, or in another planet, should we advise the water-carriage system? I have thought this subject over very earnestly lately. The advocates of the water-closet system urge that water, as a vehicle to carry the refuse, commends itself to us on the ground of cleanliness and cheapness. They would compare, and do compare, the natural power of gravitation, such as is made use of in the water-closets, with an organisation of men and carts, such as is required, for instance, by the midden system. I confess the advantages at first sight are all on one side, but I must say there are some facts which point in the opposite direction. Diluting with water is the very best known method of rendering whatever is valuable in sewage practically worthless, and sometimes an ungovernable nuisance. The excreta of animals are no doubt intended for the food of plants, and, again, for us through their intervention. Of course, do what we like, do what we please, nature will assert herself and assert her plans, although it is certain we do our very best to embarrass nature by meddlesomeness, but the nutritive food of the plant we drown with water, and then our ingenuity fails to deal with the filthy mixture. We cannot utilise it unless we abandon all sanitary precautions. It pollutes our air; it may render our ground a simple stinking morass, and defile our watercourses. Let me put it to you; here in London 30 gallons of water per head is brought from pure sources, let me say, at great cost, with vast engineering skill, filtered, and perhaps refiltered with extraordinary care, stored with scrupulous anxiety, analysed by one chemist after another, and what for? About one-ninetieth part of the water is used for drinking purposes, and a large quantity is destined to be the mere diluent of our sewage, to perplex us by its uselessness, and to steal our health with the perpetual nuisance it creates.

The CHAIRMAN said, although Dr. Tidy, in his spirited and thorough treatment of this subject, had said much to which everyone who heard him must agree, there were, no doubt, other points on which many would desire to answer him. He therefore anticipated much benefit from the discussion which would follow, and of which due notice would be given. The present time was peculiarly appropriate for dealing with the subject, as it was now awakening that attention on the part of the public which it ought to have received long ago. He would now simply move a vote of thanks to Dr. Tidy for his admirable address.

The resolution was carried unanimously, and the proceedings terminated.

Miscellaneous.

COLONIAL AND INDIAN EXHIBITION.

Last week, on the expiration of his Agent-Generalship for Victoria, Mr. Murray Smith, C.M.G., sailed for Australia. Pending the arrival of the Honourable Graham Berry, who will succeed him both as Agent-General and as Executive Commissioner for the Exhibition, Mr. Joseph Bosisto is Acting Executive Commissioner for Victoria.

RECEPTION COMMITTEE.

On Monday, April 12th, a meeting of the reception committee was held at the Society of Arts. There were present the Duke of Abercorn, C.B., in the chair; the Lord Mayor; Major-Gen. Sir Henry Rawlinson, K.C.B.; Sir John Coode; General Sir Selby Smyth, K.C.M.G.; Sir Daniel Cooper, K.C.M.G.; Major-General Sir Peter Lumsden.

G.C.B.; Sir Charles Tupper, G.C.M.G.; Lieut., General Sir Harry Lumsden, K.C.S.I.; Lieut.-Gen. Sir Samuel Browne, K.C.B., K.C.S.I., V.C.; Lieut.-Gen. Sir Henry Daly, K.C.B.; the Duke of Manchester, K.P.; Sir George Birdwood; Colonel Sir Owen Tudor Burne, K.C.S.I.; Lieut.-General Sir Charles Brownlow, K.C.B.; Major-Gen. Sir Richard Pollock, K.C.S.I.; Sir Charles Hutton-Gregory, K.C.M.G.; Mr. Arthur Hodgson, C.M.G., general secretary to the committee; Lieut.-General Henry Burne, C.B., and Mr. H. Trueman Wood, secretaries. Mr. Edward Cunliffe-Owen, assistant secretary to the Royal Commission, also attended. The committee considered a report from the sub-committee as to the arrangements which could be made for excursions for Colonial and Indian visitors. Mr. Somers Vine, the official agent of the Exhibition, attended, and reported to the committee the arrangements which had been made with the railway companies with the view of affording extended facilities for railway travelling to all Colonial and Indian visitors coming to the Exhibition. The Chairman reported that, in accordance with the wishes of the committee, and with the approval of H.R.H. the Prince of Wales, he had communicated with the mayors of some of the chief provincial cities, asking if they would arrange for visits of parties of distinguished visitors. It was resolved that a subscription list should be opened; and the hope was expressed that those who have enjoyed the benefit of Colonial hospitality will avail themselves of this opportunity of contributing to the entertainment of those who come to England from the Colonies and from India, for the purpose of visiting the Exhibition.

CONFERENCES AND LECTURES.

The first meeting of the Conference Committee, appointed by H.R.H. the Prince of Wales, was held on Tuesday, the 13th April, at the Society of Arts. There were present the Duke of Manchester, K.P., Chairman; Sir Frederick Abel, C.B., D.C.L., F.R.S., Vice-Chairman; the Hon. Sir C. Tupper, G.C.M.G., C.B.; Sir Saul Samuel, K.C.M.G.; Joseph Bosisto, Esq., J.P.; Sir A. Blyth, K.C.M.G.; the Hon. J. F. Garrick, C.M.G., Q.C.; Sir F. Dillon Bell, K.C.M.G.; the Hon. James E. Mason, M.L.C.; Sir C. Mills, K.C.M.G.; Lieut.-Col. Edmund Palmer; A. N. Birch, Esq., C.M.G.; J. A. Despeissis, Esq.; Sir Rutherford Alcock, K.C.B.; G. H. Hawtayne, Esq.; A. J. Adderley, Esq., C.M.G.; Sir James Marshall; Sir V. Houlton, G.C.M.G.; Hamilton Lang, Esq.; H. Trueman Wood, Esq., M.A., Secretary. Mr. Edward Cunliffe-Owen, Assistant Secretary to the Royal Commission, also attended. The Committee considered the question of holding conferences and lectures at the Exhibition, and appointed a small sub-committee to prepare a scheme. The Committee hope to arrange for a series of lectures or papers on the different classes of products illustrated in the Exhibition, and they hope to be able to secure the assistance of qualified experts to deal with such subjects as food resources, timber supply, agricultural resources, and textile fibres. It is also proposed to arrange for the reading of papers on the resources of the Colonies individually.

CEYLON.

The Executive Commissioner for Ceylon is Mr. Arthur N. Birch, C.M.G.; and Mr. W. E. Davidson, the Honorary Secretary, is busily engaged superintending the installation of the exhibits. The General Committee at Colombo is presided over by the Hon. Sir Arthur Hamilton Gordon, G.C.M.G., and includes amongst its members the Government Agents for the various provinces of the island, the Director of the Botanical Gardens, and the Chairmen of the Chamber of Commerce, the Planters' Association and the Agricultural Association. Sub-Committees also represent the different provinces.

Of the exhibits from the "Spicy Island," the most important will undoubtedly be the representation of the planting industry, to which Ceylon owes much of its past prosperity and to which it will, it is hoped, be much indebted in the future. The collection of the exhibits has been placed in the hands of the Planters' Association of Ceylon; and tea and coffee will here be more adequately represented than at any previous exhibition.

A handsome building, designed by Mr. J. G. Smither, to be known as the Ceylon tea house, has been erected in the gardens between the court and "Old London." It will be devoted to the sale, exclusively, of these Ceylon products.

The entrance to the court will be through a Kandyan porch in carved woods, flanked on either side by a dwarf wall, pierced and ornamented in the fashion of the ancient decoration of Kandy. The porch and wall are faithful representations of portions of the *Daladá Máligáwa*, the Buddhist Temple of the Sacred Tooth. On either side of the porch, the first exhibits to catch the eye will be, appropriately enough, trophies of the chase, for Ceylon is perhaps the most accessible country for sportsmen in search of big game. On the right hand, charging out of a jungle with unlifted trunk, will be a notorious rogue elephant, shot expressly for exhibition here. On the left will be represented the leopard, elk and varieties of deer, grouped with the gaudy birds of the tropics.

The decorations of the court have been faithfully copied, both in colour and design, from the Buddhistic art of Ceylon. Facing the entrance will be a colossal gilt figure of Buddha, sitting in the attitude of contemplation, the representation being especially appropriate as coming from a country where the doctrines and the learning of Buddhism have been maintained in their highest purity; and a special case will be devoted to a series of Buddhistic figures and ornaments. Below this figure stands a gateway, elaborately carved in ornamental wood, an exact reproduction of the principal gateway at *Yápahu*, an ancient capital of Ceylon, whose ruins, though not so majestic as those of some others of the buried cities of the interior, are the most picturesque of any.

On the left of this gateway will be ranged a collection of the timbers of Ceylon. Some two hundred "hand specimens," so cut as to show the grain in every section, will be backed by specimen planks of ornamental and cabinet woods, such as calamander (or coromandel), ebony, tamarind, and satinwood. On the other side will be seen the same native woods when carved by native carpenters into cabinets and articles of furniture. This group will be relieved by a collection of elephant tusks mounted on stands of ebony and calamander.

Precious stones, especially those for which Ceylon is famous—the catseye, sapphire, ruby and pearl—will be represented by a collection which will include some of the finest gems in existence. On stands, adjacent to the central jewel cases, will be arranged specimens of the filagree gold work of Jaffna, and of the *repoussé* silver work of the Kandyan districts, as well as characteristic sets of Sinhalese and Tamil jewellery, and a special collection prepared by the Kandyan Art Association. There will also be shown, in the front half of the court, an exhibit of lace—the making of which is an important industry in the maritime provinces—as well as tortoiseshell work and ornamental work in porcupine quill, carving in ivory, ebony and cocoanut (the atter a speciality of Ceylon) and a collection of the quaint Kandyan pottery and of the painted masks used in Sinhalese drama. Basket and lacquer work will appear in this section; and a number of paintings and photographs on the walls will supplement and illustrate the table exhibits. Models of fishing canoes and boats of the pearl fisheries, &c., will aid to illustrate the industries and peculiarities of the people.

The second half of the court (which is divided by a cross thoroughfare) will be mainly devoted to exhibits of the economic sections. Plumbago, the only mineral of Ceylon which is at present remuneratively worked, will be adequately shown in commercial samples, and by photographs of the industry and its uses. Cinnamon and the products of the cocoanut palm, the main stay of low country cultivation, will be represented by complete collections. A model distillery and casks, containing the various qualities of the spirit, will show the arrack industry as befits its importance, considering the revenue derived by the Government from the arrack farms in Ceylon, and the large export of arrack to Southern India.

Mention must also be made of the unique collection from the Maldive Islands acquired from Mr. Rosset, a German traveller who has made the group his special study.

Several fine examples of ferns, sent over from Ceylon some months ago, have been housed during the winter by the Royal Horticultural Society at Chiswick.

Six Sinhalese, two of them expert cabinet-makers and carpenters, have arrived, and will be employed in the court during the Exhibition.

TELEPHONES IN EUROPE.

The *Bulletin International* publishes the following statistics respecting the number of networks of telephones and of subscribers in Europe on the 31st December, 1885:—

	No. of Networks.	No. of Subscribers.
Great Britain	89	15,114
Germany	91	14,733
Italy	16	8,346
France	20	7,175
Sweden	15	5,705
Russia	20	5,280
Switzerland	36	4,900
Belgium	7	3,365
Austria	11	3,032
Holland	8	2,493
Denmark	2	1,370
Spain	3	594
Portugal	2	350
	320	72,457

No telephones have as yet been established in Turkey, Servia, Bulgaria, Roumania, Greece, Montenegro, or Grand Duchy of Luxemburg.

In Asia and Africa several networks of telephones have been established, viz., at Rangoon, Singapore, Columbo, Madras, Calcutta, Bombay, Maulmain, as well as in the Mauritius.

In Egypt, telephonic services have been established at Both Alexandria and Cairo, and number 431 subscribers. In the United States the telephone is in general use, and the fifteen principal cities alone contain 30,000 subscribers. At Buenos Ayres there are 1,544 subscribers, and 389 at Monte Video.

Correspondence.

STATUE OF COLUMBUS AT THE COLONIAL AND INDIAN EXHIBITION.

You announce that in the West Indian Section there will be a statue of Columbus by an Italian sculptor. Will there be in the North American Section a statue of his predecessor, Cabot, or for the Pacific side, of Drake? Will there be in the Australian Section a statue of Captain Cook?

The English sculptor who would send a model of one of these would most likely get a commission from a colony, and another for the Embankment here.

HYDE CLARKE.

32, St. George's-square, S.W.,
10th April, 1886.

General Notes.

Technical Instruction.—The *Société Philomathique*, of Bordeaux, have organised an International Congress on technical instruction, which will be opened on the 20th September next at Bordeaux.

Exhibition at Salzburg.—An exhibition of works of art will be opened at Salzburg on the 1st June next. All works of art must be sent in by the artists themselves, and not by dealers.

Musical Pitch.—At the last meeting of the Council of the Tonic Sol-fa College, Mr. A. J. Ellis, F.R.S., explained the condition of the uniform pitch movement, and it was resolved, with only two dissentients, that the French pitch be adopted as a standard in the examinations of the College. The Tonic Sol-fa Agency, 8, Warwick-lane, from whence tonic sol-fa teachers mainly procure their tuning forks and pitch pipes, now supplies instruments tuned to the French pitch. Mr. A. J. Ellis has tuned a standard fork, which is kept at the agency for reference.

Machine for Sheep-shearing.—A machine for shearing sheep is said to be in successful operation in Victoria. It is made of brass, in the shape of a small trowel. The motion is actuated by a small turbine wheel, about three inches in diameter, geared into another wheel, on which is fixed a cutter. In front is a comb, serving as a guard against cutting the skin. The steam is conveyed from the boiler by an india-rubber tube, which is double, having one inside the other. The inner one is the injection, and the space between the two the ejection. The machine is used in the same fashion as the shears, but cuts, it is stated, much quicker and far cleaner, without the least danger of injuring the fleece or sheep.

MEETINGS OF THE SOCIETY.

CANTOR LECTURES.

The Fifth Course will be on "The Arts of Tapestry Making and Embroidery." By Alan S. Cole.

Lecture III. — April 19.—Embroidery — Two Classes: Embroidery on one side of a material; on both sides — Indications of wide-spread use of Embroidery, and same form of stitches—Long practice of the Art by Mohammedans, Chinese and Japanese — Influence of Christian Ecclesiastical Establishments in developing Embroidery, and Designs for it, in Europe—Importance of considering Embroideries in respect of their workmanship and design—Analysis of Stitches—Simplicity of classification—The numerous names given to works of technical similarity—Specimens of Embroideries of different times in respect of Articles of Use and Costumes—Résumé.

MEETINGS FOR THE ENSUING WEEK.

Monday, April 19...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. (Cantor Lectures.) Mr. Alan S. Cole, "The Arts of Tapestry-making and Embroidery." (Lecture III.)

Actuaries, The Quadrangle, King's College, W.C., 7 p.m.

Inventors' Institute, 27, Chancery-lane, W.C., 8 p.m. Mr. J. T. Roe, "Automatic Railway Carriage Couplings."

Medical, 11, Chandos-street, W., 8½ p.m.

Asiatic, 22, Albemarle-street, W., 4 p.m.

Victoria Institute, 7, Adelphi-terrace, W.C., 8 p.m. 1. Professor Post, "Syrian Meteorology." 2. Lecture by Mr. Boscawen.

Tuesday, April 20...Civil Engineers, 25, Great George-street, S.W., 8 p.m. Mr. Henry Ward, "Brick-making."

Statistical, School of Mines, Jermyn-street, S.W., 7¾ p.m. Professor Leone Levi, "The Progress of Joint Stock Companies with Limited and Unlimited Liability in the United Kingdom during the Fifteen Years, 1869—1884."

Pathological, 53, Berners-street, Oxford-street, W., 8½ p.m.

Zoological, 11, Hanover-square, W., 8½ p.m. 1. Mr. J. Bland Sutton, "Specimens of Diseases from Animals in the Society's Gardens." 2. Dr. O. Finsch, "A new Species of Wild Hog from New Guinea." 3. Mr. A. Smith-Woodward, "The Relations of the Mandibular and Hyoid Arches in a Cretaceous Shark (*Hybodus dubrisiensis*)."

Wednesday, April 21...Meteorological, 25, Great George-street, S.W., 9 p.m. 1. Ven. Archdeacon Wynne, "The Climate of Killarney." 2. Lieut.-Colonel C. K. Brooke, "Note on the Probability of Weather Sequence." 3. Capt. Maurice T. Moss, "Account of the Cyclone of June 3rd, 1885, in the Arabian Sea." 4. Mr. Rupert T. Smith, "Results of Solar Radiation Observations in the Neighbourhood of Birmingham, 1875-1884." 5. Mr. A. W. Sinclair, "Results of Meteorological Observations made at Kwala Lumpor, Malay States, 1884."

Geological, Burlington-house, W., 8 p.m. 1. Mr. A. B. Wynne, "A Certain Fossiliferous Pebble-band in the 'Olive Group' of the Eastern Salt-range, Punjab." 2. Mr. F. L. Cornet, "The Upper Stages of the Chalk in the neighbourhood of Mons, and on the Phosphatic beds associated with them."

Royal Society of Literature, 4, St. Martin's-place, W.C., 8 p.m.

Archæological Association, 32, Sackville-street, W., 8 p.m. 1. Mr. W. de Gray Birch, "Notes on Two Sculptured Slabs in Chichester Cathedral." 2. Mr. J. T. Irvine, "The Saxon Tower of Barnack Church."

Civil and Mechanical Engineers, 7, Westminster-chambers, S.W., 7 p.m. Mr. C. T. Walrond "Some Details of Drainage and Water Supply."

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FRIDAY, APRIL 23, 1886.

All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

NOTICES.

CANTOR LECTURES.

The third and last of the lectures upon the "Arts of Tapestry-making and Embroidery," was delivered by Mr. Alan Cole on Monday evening, 19th inst. The special subject was embroidery. Embroidery is an ornamental enrichment worked with a needle and threads on to a material. It divides itself into two classes, one in which the enrichment is done on one side only of a material, the other in which it is done equally well on both sides. The needle was known to early man, and its evolution through successive stages of bone, wood, bronze, and steel may be traced. The work of the child in a civilised community corresponds with that of the individual adult belonging to a more primitive people. The same condition applies to pattern; and an instance of this was given in an English schoolgirl's sampler of the 17th century, and adult peasant work done in remote Norwegian villages. Old Latin titles of different sorts of embroidery had been used latterly as a basis of classification of stitches. There were the "opus anglicum," the "opus pulvinarium," the "opus plumarium," the "opus pectineum," and the "opus consutum." These terms, however, were practically of little use for indicating technical characteristics. The lecturer showed diagrams of some dozen stitches, and remarked that not more than four distinctive stitches were involved in embroidery generally. A series of diagrams, photographs from good specimens, illustrated classes of work, such as drawn thread and cut work, patch and *appliqué* work, raised and padded work, and quilting. Reference was made to the unique example of patch work described by Mr. Villiers Stuart, and found to have been made for an Egyptian queen 950 B.C. Indian embroiderers at work with gold thread were displayed, and the technical similarity between their work and European ecclesiastical orphreys, funeral palls and altar frontals, was described. Specimens of modern work, notably a panel of cut linen made in Ireland this year for the Queen, were shown, chiefly with the view of demonstrating a survival in the use of stitches centuries old.

A vote of thanks to the lecturer for his interesting course of lectures was carried unanimously on the motion of the Chairman.

The lectures will be printed in the *Journal* during the summer recess.

INDIAN TEMPLE.

With the present number of the *Journal* is issued as a supplement, a print taken from one of the series of drawings of old buildings in India which were exhibited at the reading of Mr. Gibbs's paper on the "History of Archæology in India" (see *ante* p. 555).

Proceedings of the Society.

CANTOR LECTURES.

SCIENCE TEACHING.

By Prof. Frederick Guthrie, F.R.S.

Lecture I.—Delivered February 15, 1886.

SCIENCE AS AN ELEMENT IN EDUCATION.

Introduction.

Allow me very shortly to explain my position here this evening. I have had the great good luck to have been, for the last 30 years, teaching chemistry and physics. As an examiner for the Science and Art Department, it has been my duty to examine or look over the examination of above 100,000 candidates in physics. I have had the privilege of knowing face to face most of the best teachers of science at home and abroad. And, lastly, it has fallen to my lot to have somewhat altered, and I hope bettered, the ways followed in teaching practical physics.

Therefore, the great difficulty I feel in speaking about this matter does not come from want of opportunity or experience, but from a feeling that the task is one of overwhelming vastness and the outcome one of mighty weight. This difficulty has had, however, to be overcome, for I feel that the public has, by this time, a right to ask an account, however short, of my work and of my thoughts. And so I give such account here, in the simple hope that thereby others may think and work in the same way. I know of no better plan for reaching those whom I wish to reach than through this Society, which has always been well to the fore in matters of education.

GENERALITIES.

At the outset of our inquiry into science teaching, we are, of course, met by the old question as to the purpose of education. There are those who regard education as an intellectual arming and equipment for the battle of life. Others look upon it rather as an end than as a means. The first would supply to the individual only those weapons which he is likely to require in making his way in the world. The second advise a wider, and therefore more dilute, education (the time given to education being the same), and would relegate the acquirement of specialities to the exigencies of the career.

I suppose that to this audience it need scarcely be insisted on, or indeed to any educated audience now-a-days, that both of these views are fallacious on account of their partiality. The most favourable product of the first is the "successful" specialist, who is for the most part a burthen to himself. The second gives us the shallow "prig," who is for the most part a burthen to his fellow-creatures.

A good citizen—and by citizen I mean of course a citizen of the world—must be a man of large sympathies. Though colour-blind, he must have common feeling with painters, and, if tone-deaf, the works of musical composers must not be without interest to him. And through all it must not be forgotten that distinction is a noun of limited number. The time may come when they who know as much mathematics as Newton shall be counted by scores. The time has come when they who know as much geometry as "Euclid" are to be counted by thousands; and they who know as much chemistry as Dalton, by tens of thousands. But we are as badly in want of Newtons, Euclids, and Daltons as ever.

Here as elsewhere, it appears that an apparently insuperable difficulty is half surmounted when fairly confronted. It is, without doubt, the conviction of those whose opinions of to-day will count as truisms to-morrow, that, up to a certain stage, and as far as the presenting of opportunities is concerned, the education of one should be the education of all.

Liberal variations should be recognised in accordance with the tastes, and especially with the distastes, of the individual: yet, there is a certain nucleus of somewhat indefinite boundary which should be offered habitually to each. When I say "somewhat indefinite," do not, I pray, imagine that I want to shirk a difficulty; on the contrary, my purpose is to accentuate and try to deal with it.

It is perhaps in matters of taste which, in their developments, become Fine Arts, that the greatest eagerness to learn, and the greatest antipathy against learning, are manifested by the individual. And it is therefore that I should relegate such matters to the later stages of a general education.

When, accordingly, I shall have to advocate the introduction of drawing into the very earliest stages of education, it will be understood that I am not considering it then and there as a fine art, but as a mere record of the perception of things. It is in regard to subjects which involve taste that the course should be least rigid. If the arithmetical course, for instance, were less rigid, the parent might, indeed, be spared the ignominy of having to confess to his child that he (the parent) does not know how many pennyweights there are in a kilogram. Think how we parents have to shuffle, and how we scarcely recover our dignity after we have, more or less clandestinely, referred to books. This is bad. But, to my mind, it is far worse to have to listen to some poor little mortal trying to acquire some one or two set pieces on the piano, for hours daily, and for months yearly. And the excess of pain in the second case over that in the first is due not to the fact that our own physical agony is greater than our moral ignominy, but that in the second we see a long vista of hopeless effort before the little victim.

Most undoubtedly educationalists will have to distinguish far more clearly than heretofore between general or abstract knowledge on the one hand and special or arbitrary information on the other. There are certain sciences which are sometimes called exact sciences, but which I should prefer to call universal, or general sciences. These are mathematics, mechanics, chemistry, physics. The less general or more particularising sciences are such as mineralogy, geology, biology; while among the highly special, that is, occasional sciences, are such as geography, geology, astronomy. The so-called laws, which I should prefer to call generalisations or rules of mathematics, chemistry, and physics hold good, as far as we know, throughout the universe. On the other hand, the distribution in space of the masses of matter which we call stars and planets is trivial. The local geographical phenomena are in a sense "accidental." The course of the Thames is "arbitrary," and so on. In the cosmos of things we may be sure that it is of infinitely greater moment that chloride sodium is soluble in water than that there is a "silver streak" between England and France, or that Mount Everest is a few yards higher or lower than Dwalagri. Of course I wish to speak with every reverence of the Channel and the "heavenly bodies" and of mountain chains. But the fact is that they have to be relegated to the occasional ward of our great workhouse —the universe.

SCIENCE IN PROFESSIONS AND OTHER OCCUPATIONS.

It is the legitimate boast of this country that the highest offices of the State, excepting of course those pertaining to the Throne, are open to the child of the lowest birth or the deepest poverty. It is as certainly one of the greatest scandals of the country that such offices are open to and have often been held by persons of the very lowest culture and ability. As long as this is so, as long as a man may aspire to become, and actually become, a judge, a bishop, an ambassador, a colonial governor, and yet be and remain on the whole an ignorant fellow, so long will the educational establishments, whether schools or colleges, in which such persons have received their so-called educations, remain much as they have been. In speaking of State appointments, of course I do not allude to what may be called ministerial appointments. Our system of governing by "Parties" throws open such offices to the very lowest type of political partizan, the most emasculate of henchmen. The subject is not a pleasant one. But it is no use shutting our eyes to the fact that, according to the present system, the highest interests of a large part of the education of our country may and does lie in the hands of very ignorant people.

Nor is the evil of which I have spoken confined to State appointments, which, though of great influence, are few in number. There are hundreds of men who are far more clearly and illustriously viewed in the world's focus than State officials or Government servants. But think of them! Is it not rare to find an artist, either literary, pictorial, musical, or other, whose conversation does not bore you on account of its narrowness? Unquestionably this is so, and unquestionably the best in each profession are the first to admit it. Even in a profession such as that of medicine, where we have a right to expect to find at all events scientific culture, we find rarely anything of the kind. Owing to the fact that the medical profession has had for centuries our healths in its hand, the ignorant naturally have recourse to the doctor in matters of health; nay, are in a manner compelled to do so. Accordingly, and for instance, you find our vestrymen appointing as public analysts any kind of broken down medical man, who does not know one end of a test tube from the other, although he may know on which side his bread is buttered.

Even the surgeon, whose profession is eminently scientific, is too often shamefully ignorant of the very elements of chemistry, physics, and mechanics, the three general sciences which, together with the trivial science of anatomy, make up the whole of the science of his profession.

On the Bench the want of scientific culture is painfully conspicuous. Speaking under correction, I suppose I may go so far as to say that, theoretically, law is founded upon justice; that it is, at all events, a more or less crude effort towards that rather illusive ideal. As a matter of fact, lawyers will tell you, with beaming countenances, that English law is an inchoate hotch-potch of enactments and precedents, obsolete, imaginary, supplementary, and contradictory. In fact, the idea of right is replaced by an indefinite number of rules of an arbitrary character. It is here to be well noted that the study of such arbitrary information—I will not call it knowledge—has and must have a narrowing influence; it deadens the mind, as it must deaden it, to the perception of principles. Now, the laws of nature are not Parliamentary enactments, and a judge, in his questions to witnesses, and in his remarks and summings-up, when scientific matters are before him, often appears at great and painful disadvantage through his efforts to codify nature. Frequently, indeed, his remarks, as reported, are the funniest things in a daily paper. Of course the efforts of the judge are greatly aided by counsel, who are supposed to be able to master any question in any science in twenty minutes. I am ashamed to say how justice is aided by the "scientific experts," generally of third or fourth rate standing in their professions—well, this is also an unpleasant subject. As to the final outcome of the suit, as a Court generally reverses the decision of the one below, a great deal depends upon whether there is an odd or even number of Courts between the first and the last. But I for one do not want either to ridicule or pity that which should be sober and majestic. And if it is not possible that every judge should have scientific training, it would be surely advisable that one or two should have it, and that causes involving scientific questions should be brought before such alone. Perhaps this end can only be reached by making the qualifications for the Bar include at least an elementary knowledge of one or two sciences, and this again, could, perhaps, be only effected by subdivision of Courts, and special methods of qualification. Of course, for the professional advocate who displays ignorance, one need not have the same pity as one has for the judge in the same predicament. We know that the judge in this country is very nearly always just in intention, and, according to his lights, just in his judgments. But meanwhile the public suffers. Gross wrong is inflicted, and our Courts of law, in cases in which scientific questions are considered, are sometimes Courts of ignorant tomfoolery.

SCIENCE IN THE SERVICES.

Some years ago, to be an officer in the army or navy was, in most branches of those services, to incur the suspicion of being an ignorant and, so far, a vulgar fellow. It was the exception when such an individual could be admitted into intellectual or refined society without discomfort. Matters have now so greatly changed that in some branches at least of the services men of the very highest stamp are rather the rule than the exception. Of course, while the conditions which have effected this class have had so elevating an effect on the services, they have had for a time, a bad effect in other directions. Many a rich and idle lout who would formerly have been hidden for a large part of his time in the barracks, finding its doors shut in his face, degenerates prematurely into the civil fribble and bore.

The civil services have profited no less than the military and naval. It has been found already advisable that, in certain Government departments, the *employés* should know something of the matters with which the departments concern themselves, besides having a certain general culture other than that of the Latin grammar. I see no reason why an educational sifting and sorting should not be demanded by the State in the case of all professions having State support. By support, I do not mean merely those who receive State pay, but those who, like the legal, medical, and ecclesiastical, have State rights and privileges.

SCIENCE IN THE UNIVERSITIES.

As it is from the Universities that the so-called liberal professions are to a great extent recruited, I am bound to speak a word or two as to the position of science in them.

Of the teaching of science at the Universities of Oxford and Cambridge I need say but little. The weighty list of names illustrious in mathematics and astronomy which the latter of these can show, might be considered sufficient to redeem it from the reproach of neglect of scientific culture. But in such an estimation we are justly to consider the boundlessness of the opportunities, the vastness of the means, and stringency of the duties. Regarded under this light, and in spite of many notable examples to the contrary both in the past and in the present, it does not admit of a shadow of doubt but that on the whole these opportunities have been greatly wasted, these means wrongfully applied, and these duties wantonly neglected.

These Universities were primarily intended for the teaching of those branches of knowledge which have since developed into science. I imagine that education as understood for instance by the Greek was mainly athletic, scientific, æsthetic, literary, and political; literature in its widest, politics in its narrowest sense. Their philosophers looked around, as all philosophers are bound to do, as most have done excepting Kant and Comte, whose philosophy, based upon insufficient scientific knowledge, crumbles to pieces when touched. The Greek philosopher got much of his honey from abroad; but the comb he built for it was geometric, universal.

It was for the purpose of understanding such scientific writers as Aristotle, Euclid, Archimedes, that the "schools" were founded and supported. Then we have

Plato, who seems to me to be for ever hanging on to the hem of the garment of the Great Master. Much of this of course came through the Latin language. But shortly the means became the end. The language was found to contain a literature. Then a curious but not unnatural event happened. The means of acquiring knowledge in a foreign language degenerated—I will use no other word—into the study of that language, redeemed by the simultaneous acquirement of its marvellous literary treasures. Hence arose the dreadful school of dogmatic grammarians and pseudophilologists. Their day is passing, because grammar and philology are becoming sciences as exact at least as geology or biology.

It is, I think, hopefully to be expected that we shall soon lose sight of those dreadful creatures who used to wobble their heads over what they in their ignorance conceived to be a false quantity; often mistaking accent for quantity, partly through want of scientific training, partly through ignorance of the knowledge acquired by other nations. Such creatures were, perhaps, the natural outgrowth of the state of transition between Aristotle and Darwin, between Archimedes and Joule.

The really frightful outcome of all this was that, for a time, information took the place of knowledge; and the culture of the University was little beyond that of the cabman, the postman, or at best that of the librarian.

Perhaps the very greatest revelations made to man in the historical past took place in the last quarter of the last century and in the first half of the present. It was then that chemistry led us to understand the composition of matter. It was then that physics developed the coordination of the known forces and showed the existence of a new one. It has been during this time that biology has been changed from the chaos of natural history into a hopeful cosmic science.

In the matter of chemistry, the record of what we owe to these Universities is shamefully short. While the intellectual world was ringing with the discoveries of Priestley, Black, and Lavoisier, the Universities were concerned with the insignificant squabbles of philologists. And the stunting effect of one-sided culture was never more strikingly exhibited than by the fact that because so-called scholarship was the only branch of culture held in esteem; so, and as a natural consequence, English scholarship fell, on the whole, far behind that of several other nations. While Faraday and Dumas, Liebig and Darwin were at work, what was, say, Oxford doing? Future generations will scarcely credit it. The leading lights in that University had nothing better to do, apparently, than to issue and discuss tracts on the difference between "tweedledum and tweedle-dee."

It is idle to contend that the genius of our nation is unsympathetic in scientific matters, for we can show a muster-roll of chemists and physicists which will compare favourably in quality, if not in number, with that of any other nation. The two Universities, which should be the pioneers of intellectual advance, proved themselves to be very laggards. These "eyes of England" were become so imperfect of vision that men began to fear they suffered from the defective power due to old age, and that nothing would be ever clear to them but the distant past. In those days, although there were great chemists and physicists in this country, there were no schools of those sciences. They who, like myself, some thirty years ago, had a passionate yearning towards and a determination to study them, had to go to Germany or France.

And even now, in spite of many vigorous efforts and encouraging successes, in spite of the notable men who have filled, and are filling, the posts of teachers, the Universities under consideration cannot be considered as centres of science. The very best men connected with the Universities are the first to admit this. For such centres, those who wish to become masters of the craft have had to look abroad, or to the metropolis, or to our provinces.

As to our own two metropolitan colleges, speaking of them collectively, they have been of very great value. They have often elected their teachers according to their qualifications: perhaps they have been rather more scrupulous in this respect than the average of educational institutes.

They have been attached to day-schools on the one hand, and, as far as science is concerned, to hospitals and medical schools on the other, and it is this which has given them strength. For high education for its own sake has scarcely yet taken root in London.

In regard to the provinces, the prospect has been rapidly brightening. In Birmingham, Bradford, Bristol, Leeds, Liverpool, Manchester, Newcastle, and Wales most excellent colleges where science is taught, aye, and learnt, are in beneficent activity. It was high time. These centres of industry demanded the knowledge. Such knowledge was not to be got at the older Universities. It could be obtained only in Scotland, in Dublin, and in the two chief London colleges; elsewhere only abroad. Even in a great place like Manchester, where the undertaking was favoured by a munificent endowment, the progress at first made was very slow. I remember when some years after Owens College was started, say about the years 1857 and 1859, I had the honour of serving as assistant to the then Professor of Chemistry. During those two years the subject of physics was not taught at all. Now there are three or four professors and a number of assistants.

Again, there are the Queen's Colleges in Ireland, the Naval College in Greenwich, and the Engineering College at Cooper's Hill.

As to the Scotch Universities. Again, I do not speak without experience. I served for two years as assistant in the chemical laboratory of the University of Edinburgh. In those days (say, 1860 and 1861) the main stay of the chemical laboratory was the medical faculty. As to a physical laboratory, it did not then exist, or had only begun to exist. This, if I remember right, was the University of Hope, of Black, of Forbes. The Universities of Dublin and Glasgow, however, distinguished as they may have been in their teachers, have still to make a historical reputation as science schools.

It would perhaps be premature to speak of the success and usefulness of that courageous undertaking, the Central Institute of the City and Guilds of London. One thing about it is certain and pretty obvious. Unless such an enterprise purposes to become a manufacturing concern, and so compete in the market with companies and private firms, it will have to restrict its usefulness to the teaching of pure science, abstract and applied, and electing the kind of science which is of most use in a few special arts. It cannot teach handicrafts, though it may do immense good to the learners of handicrafts. Final technical training can only be got in the workshop, where marketable wares are made.

Within a stone's throw of this Institution there are the Government Science Schools, with which I am connected. I suppose that the two institutions will be teaching pretty much the same things in large parts of such subjects, as mechanics, chemistry, mathematics, and physics. The municipal school has specialities of which we do not treat; and we again have specialities, such as geology, metallurgy, and biology. As a Government servant, I must say no more than this, in my opinion there has been somewhere a certain waste of energy. Certainly, in as far as success in the Central Institution can be guaranteed by the ability and zeal of the teaching staff, such success is assured. While then at present I can only wish success to this Central Institution, it gives me real pleasure to recognise and applaud the success of the Finsbury College and several of the special chairs endowed elsewhere from the same fund.

Science in the Colonies.

In a recent work of fiction, one of my most esteemed literary friends complains with gentle pathos that the "professor of physics considers his science to be the one noble occupation, all in capitals." It so happens that this gentleman and I were colleagues as teachers in a college in one of the colonies, which, for the sake of dissimulation, I may call Palmyra. The industry was entirely based on the sugar growth and manufacture; our pupils were of very varied and mixed European, African, and Asiatic races. We teachers were "expected to make ourselves generally useful." Thus, while I was supposed to teach chemistry, physics, and the "natural sciences," my more gifted friend taught, amongst other things, Latin, Greek, mathematics, and English literature. Now, while I do not admit that I am open to the charge of considering physics as the one noble occupation, I have no doubt I have used—as is my occasional habit—language of some strength. For it struck me forcibly at the time (and the conviction has remained with me ever since), that as the material soil of the place was unsuited to the oak, the olive, and the vine, so was the attempt to plant an academic grove of thought a waste of energy. To teach a poor little negro child the history of Rome, to make the Chinese lad translate Sophocles, might be a *tour de force* on the part of the teacher, but could do no good to the child. And here a very solemn consideration arises in the mind of the educationalist.

In colonies, such as Canada, Australia, and New Zealand, which may, for practical purposes, be considered as settlements on unoccupied regions, the inhabitants have the educational traditions of the mother countries, and are sure to evolve the modifications suitable to their especial wants. But in Africa, and especially in India, where the natives do not at present belong to the governing race, and yet form the most important element of population, the education should be of a totally different kind. Of course I do not touch here on religious matters. In matters of literature and the fine arts it must be borne in mind that we shall waste the less time and energy the less we try to thrust our Western developments of these down the throats of the Brahmin, the Buddhist, or the Mahomedan.

Does the same apply to science? Assuredly not. The Oriental accepts our science eagerly and gratefully, because it is not more ours than it is American, German, Russian, or his own. To our customs, our sports, our literature he must always remain a stranger, because at heart indifferent to them. In our telegraphs, railways, works of irrigation, and the sciences which lead to them, he takes a far keener interest; for such sciences, being universal, are in truth as much Oriental and his as Western and ours. Truth alone is cosmopolitan, and in science only does truth reside.

My own experience in this respect is confirmed by that of all the best teachers of science in the Indian colleges. They all declare that the slow progress which education makes in that part of our dominion is not due to the apathy of the native races, but to the infatuation of those who will not or cannot see that there is anything worth learning beyond the pitiful horizon which has circumscribed their own education.

Even the consensus of opinion of science teachers has, however, only a certain weight. Take, then, the articulate requirements of an independent, intelligent, and utterly alien nation—the Japanese. Japan shows us assuredly a most wonderful instance of development. While the Western nations and America are indulging, after a temporary fashion, in the matter of Japanese art, Japan takes our science at once and as a whole, for it finds in science the one universal language—the language of nature herself. I am profoundly conscious of the services rendered to Japan by those Europeans who had the supreme happiness of being among the first to confer a great benefit on a great people. But the intellectual soil, the moral climate, had to be there, that such labours might bear such abundant fruit.

I hope I may mention a circumstance in this relationship without vanity. I cannot do so without pride, for it was with the greatest pride that I lately received a letter from the Director of Education of Tokio, after his visit to this country, asking for details about the system of instruction in elementary practical physics as pursued in the Government Science Schools at Kensington, with the view to its adoption both in the normal and elementary schools of Japan.

It comes then to this. We English may consider ourselves as forming about the average of the European races. The Japanese, on the other hand, have had for many centuries little or no intellectual intercourse with the outer world, excepting with China. Yet at once Japan accepts our science. It is as when some crystal, which has grown slowly in the darkest bosom of the earth and is then suddenly brought to light, reflects, refracts, absorbs, and polarizes as faithfully as the oldest specimen in a physical cabinet. In a couple of hundred years floods of scientific truth will be poured upon the Western world from China and Japan, unless those countries fall victims to some so-called higher civilisation, in the same sense as did Peru and Mexico.

SCIENCE IN PUBLIC SCHOOLS.

In regard to the teaching of science in the most widely known of our English public schools, we must regard it as being for the most part abortive. This has, without doubt, been brought about chiefly by the narrowness of culture of the head-masters and their subordinates.

The profession of a teacher properly understood is certainly second to none other in dignity. So long, however, as it is looked on in such schools as a mere "stepping-stone to higher things," so long will teachers shuffle through their duties, whatever they may be, in a perfunctory way. They are generally obliged to look for their main remuneration to boarders, and to hold relations with the boys and their parents which certainly, and to say the least, do not tend to independence, and are frequently scarcely consistent with self-respect. In such a school the unhappy science teacher is the worst off. If he be also a teacher of classics, who undertakes to teach science by reason of some smattering of it which he may have picked up in a desultory manner, his task is distasteful to him, and we may be sure he is not slow to contaminate his scholars with such distaste. He detests his duties partly because his ignorance is a disagreeable revelation to himself, but mainly because he feels that quick-witted lads soon discover his incompetence. I am well acquainted with the product of such teaching. If I should ask one of his pupils to describe a Leyden jar, the chances are that I shall be treated with a short history of John of Leyden, with an *excursus* relating to a celebrated American philosopher,

> "Qui cœlo fulmen eripuit
> Sceptrumque tyrannis."

I shall be introduced to Thales of Miletos, or informed as to the Greek name for amber.

If, on the other hand, a highly qualified scientific man is employed he finds himself out of sympathy, almost out of touch, with the rest of the school. The absolute necessities for teaching his science are denied to him, or grudgingly dribbled out. His colleagues regard him without any feeling of comradeship, and so again the boys get to look on him as a sort of pariah, and on his occupation with contempt. For to put the thing in a nutshell, "marks" in science do not "count." Often, indeed, attendance in the science lessons is optional, and the science master finds himself in friendly rivalry with the professional cricketer.

It has lately been my privilege to have some correspondence with one of the ablest and most successful of head-masters. This gentleman is too modest too see that his success is greatly due to the fact that while his scholarship would put him on a level with his fellows, his scientific attainments and sympathies put him a head and shoulders above most of them. Yet even he informs me that it is a common observation that the boys who come to his school to join the science classes, however apt in science they may prove to be, are often dull and "bores," and are out of sympathy with those whose studies are literary.

What a cruel farce this is! Is it not clear that a boy of the highest ability will grow intellectually stunted, and perhaps morally warped, if the only mental food offered is distasteful to him? It is as though a child had been pining for at least a little meat and had been fed on boiled rice. Such a boy might well be rickety. And are we asked to conclude from his physical state that all boys who crave for meat are stunted or deformed? Are we to infer that the craving is the cause of the physical defect? This is little short of monstrous. It is not the yearning but the neglect of it which is the root of the evil.

Of course some lads are of such strong fibre that not much permanent injury is done to them. Others partially recover in the holidays; while others again instinctively save themselves by the simple carpentry of the jack-knife and the glue-pot, or the wilder delights of the catapult, the bird's nest, the white mouse, the squirrel, or the squib. Sometimes, indeed, the self-invented recreations of a boy are pitiful. They are tacit entreaties for mental food other than that which he is receiving. These recreations which should serve as a guide to teachers in modifying the instruction, are often looked on askance as being "ungentlemanly," "bad form," or what not. The culprit is regarded in the same light as would be our rice-fed boy who had been found gnawing, to satisfy a natural and wholesome longing, some well boiled soup bone which he had begged from the cook.

It is true that not one child in a thousand is capable of becoming a scientific man. That is no reason whatever why the opportunity of learning the elements of science should not be offered to all. Such opportunities are to be given not so much for the sake of the thousandth child, nor even for the sake of the good to the community which will accrue from his career, as for the sake of the nine hundred and ninety-nine children who will have at least the chance of obtaining some scientific culture, and so be in sympathy with those upon whose shoulders rests the task of advancing civilisation. Though a boy may not be "intended" for an occupation in which science is required, and though he show little or no aptitude for it, it is, nevertheless, as unjust to hide science from him as it would be to hide a knowledge of history or literature from those who are not "intended" to become historians or authors.

When, therefore, I hear that it is proposed to open a "modern side" in one of our public schools, it sounds to me like a proposal to open a little way the door of the Black Hole of Calcutta.

Observe the vicious circle. With ignorances and prejudices such as those I have mentioned, the scholars from such schools go up to the Universities, and give to them in the main their own uncultured tone. As it is from the Universities that public schoolmasters are for the most part drawn, the bar to improvement seems strong indeed. One obvious way to break this vicious circle lies, it is true, at hand. I cannot consider it conveniently here, and I am loath to touch upon it. But this much must be said; it cannot be for the welfare of any religious body that its highest offices should be filled as often as they are from a class—the class of head-masters—which persistently and almost professionally sets its face against natural knowledge. For it is thus a premium is placed on one-sided and therefore imperfect culture at the very fountain-head of education. Still more rarely can it be for the advantage of a public school to be under the guidance of a member of a class which has, speaking generally, consistently shown both fear and dislike of nature and her interpreters. Whatever hope there may be in the future for relief in this matter, it is probable that such relief will rather be effected from the outside than from the inside.

SCIENCE IN BOARD SCHOOLS.

As to this influence from the outside—where shall we look for it? Clearly in the aspirations, ambitions, and discontents of the better classes. The better classes are the more intelligent classes, and these are, without any doubt whatever, formed from the ranks of the artisan or handicraftsman—whether of our cities or our fields—and especially from the ranks of those who have been artisans or handicraftsmen, but whose ability has advanced them, say, from the labourer to the farmer, from the carpenter to the builder, from the nail maker to the engineer, from the apprentice on a barge to the captain of a "liner." It is here, or hereabouts, that the very marrow of our nation lies. The aspirations of these classes are opposed directly and indirectly by the more ignorant classes both above and below them. The dangerous classes are the idle classes of all ranks. He would do a far greater service to the commonwealth who should give useful employment to the idle rich than he who should sweep away a thousand slums.

The Board school is the legitimate place for the education of the child of the artisan. He must and will have science for his male child. Let us see what he gets.

In the infant schools are taught reading, writing, arithmetic, and object lessons, all compulsory. In these schools the children are so young that the schools themselves are chiefly *crèches*, and we may, with some fairness, say that "whatever's best administered is best." In the infant schools, the chief change I would suggest is the introduction into them of drawing. Indeed, drawing should perhaps be the main feature of these schools. It should be the medium for the instruction in writing. I have found that a child which cannot draw or copy a straight line will draw a straight tail to a cow. And although the beginning and end of its "O's" are invariably wide apart, or else tied together in a sort of true lover's knot or double pig's tail, the child will put in the cow's eye as a very good circle. Arithmetic I would banish from the infant schools altogether.

In the Board schools proper I find seven standards which correspond roughly with the seven years' attendance of the average children.

In all of these, reading (including some history), writing, arithmetic (and needlework for girls) are compulsory; while drawing, elementary science, geography, and history, may or may not be taught specially. In standards 5, 6, 7, however, the following additional subjects may be taught, algebra, Euclid, mechanics, Latin, French, animal physiology, chemistry, physics, agriculture (domestic economy for girls). In standards 1—4 the Government examinations, both in the compulsory and optional subjects, are based upon the general proficiency of classes; while in standards 5, 6, 7, the children taking the optional subjects are examined individually with view to the teacher's payment,

This is an excellent list of subjects, and as it is notorious that the members of the School Boards are, for the most part, men and women of enlightenment, and zealous in their work, and that the managers and teachers are chosen with care, and are often of conspicuous ability, it might seem that under fairly favourable local circumstances, an excellent elementary education is provided by the State for the poorest child.

This is not so. Here is a great blot. A blot which I am going to remove. The evil consists in the narrow range of the compulsory subjects. A child may pass some years in the infant school and then pass through all the seven standards of the school proper, and yet know nothing beyond reading, writing, and figuring, except the little knowledge he may have got from the object lessons of the infant school and the history contained in his reading lessons. Think what this means! He may know that William of Normandy stumbled on landing in England; he has probably never seen a triangle. He may know how many furlongs there are in a mile; he is generally under the impression that his indrawn breath goes into his stomach, which is somewhere below his waist, and so on. In reading, writing, and arithmetic you have given him the keys of knowledge, but you have not let him even peep into its treasures.

For the subjects called optional are not so in the sense that the classes are there, and that it is at the option of the parent whether his child shall attend them. Not a bit. They are there, or they are not there, at the option of the school manager, of the school teacher —at the suggestion of the Board Inspector, or Board School Committee, or School Board.

This is exactly as it should not be. For, as a consequence, there are well-attended schools in which geometry is not taught at all, in which chemistry is never heard of, and mechanics a thing unknown. I am not exaggerating. Taking the year 1883-1884, we find that, in standards 5, 6, 7, over 325,000 children presented themselves for examination in the so-called "specific" subjects, that is, subjects which may or may not be taught in a given school, the examination being by Government and individual, the payment being by result. We find this startling discrepancy: 25,000 were examined in algebra, and 2,000 in Euclid. It is certainly not within my personal experience that, out of every thirteen children, twelve would prefer to learn algebra to every one who preferred geometry. I believe the tastes of children are rather the other way. Certainly the bulk of judicious parents would not so sacrifice their children's education as to strike such a balance. Reversing Plato's dictum, I would say, let no one leave this place ignorant of geometry. There can be no doubt but that, if these figures were further analysed, the discrepancy would be found to lie not so much in the smallness of the number of pupils in the classes of geometry as in the smallness of the number of such classes. In other words, the subject of algebra is easier to teach up to the passing standard than that of geometry. Small blame to the teacher who prefers to offer the first rather than the second.

Deplorable as is this want of balance as between algebra and geometry, such inequality is even exceeded in another case. In 1884, over 22,000 were examined in animal physiology, while only 1,200 presented themselves in sound, light, and heat, and only 1,000 in chemistry. This is not only a singular but what may be fairly called an impossible condition of things. What manner of instruction in physiology is that which ignores physics and chemistry? Everyone knows that animal physiology is little else than the biological branch of these sciences; and the more special science of biology should only (because it can effectively only) be taught to those who have a knowledge of the more general sciences. The discrepancy here is outrageous, and betrays something radically wrong in this working of the system. It is as though in an art school, which was responsible for the entire art education of its pupils, twenty should year after year be examined in oil-colour painting for every one who was examined in drawing. If there be indeed a method of teaching animal physiology which does not demand a previous knowledge of chemistry and physics, the sooner such a method is got rid of the better.

Much the same may be said with regard to the numbers examined in geography (12,700). Physical geography (unhappily called physiography) is a science. Sixteen candidates were examined in it in 1884. Can it be that in the Board schools, as in most other schools, merely descriptive geography is meant, such as the height of Popocatapetl, or the chief towns on the Yangtze Kiang?

It is certainly impossible to separate knowledge from information. Information is arbitrary knowledge. Education must, I suppose, be largely leavened with the former. The sequence of the letters of the alphabet is a thing not to be despised, any more than the cabman's acquaintance with the short cuts between Clapham and Islington. Knowledge bears to information a relationship comparable with that between friendship and acquaintance. Knowledge would be of use to us if we were transported to another planet, capable of sustaining life; information would not. Poor cabby, as such, would be at first nowhere. No doubt he would soon rise to the occasion if his fares went with him, through his general knowledge of human nature, thus most places would be "beyond the radius." I often judge of people whom I meet for the first time—and, as the events prove, not unfairly—by considering whether they would make successful savages. And I find that the man who has most knowledge would always be in advance of the man of the most information. If our tribe were on the war-path the latter might know best how to lead us to a certain river; the former would have to devise means for crossing it. There might have to be as many guides as rivers; but one, the ancestor of our engineer, would be appealed to for the means of crossing them all.

Having thus found fault with our present system of School Board education, I am bound to propose the alterations which I consider to be improvements. For brevity's sake I have put side by side in a tabular form the present scheme, and what I consider to be a better one.

PRESENT.

INFANT SCHOOLS.

All Compulsory.

Reading.
Writing.
Arithmetic.
Object Lessons.

SCHOOLS I TO VII.

Compulsory.

Reading (History).
Writing.
Arithmetic.
(Needlework: Girls).

Optional.

(*Class Subjects—Class Examinations*).

English.
Drawing.
Elementary Science.
Geography.
History.
(Needlework: Girls).

V., VI., VII.

(*Specific Subjects—Individual Examination*).

Algebra.
Euclid.
Mechanics (2 schemes).
Latin.
French.
Animal Physiology.
Botany.
Agriculture.
Chemistry.
Physics (2 schemes).
(Domestic Economy: Girls).

PROPOSED.

INFANT SCHOOLS.

All Compulsory.

Drawing.
Writing.
Reading.
Object Lessons.

SCHOOLS I. TO VII.

All Compulsory.

I. Reading (anything).
Writing.
Drawing.
II. Reading (anything).
Writing.
Drawing.
Arithmetic.
(Needlework.)
III. Reading (Biography, Novels).
Writing.
Drawing.
Arithmetic.
Geometry.
(Needlework).
IV. Reading (Natural History, Travels).
Writing.
Drawing.
Arithmetic.
Geometry.
Singing.
Geography.
V. Arithmetic.
Object Lessons.
Geometry.
Chemistry.
Mechanics, &c.
English.
French.
Singing.
VI. Object Lessons.
Geometry.
Sound, Light, Heat.
Chemistry.
English.
French.
(Needlework.)
VII. Mechanism.
Electricity.
German.
Biology.
Algebra.
French.
(Domestic Economy).

EVENING CLASSES.

French.
German.
Italian.
Latin.
Agriculture.
Mathematics.
Laboratory Chemistry.
,, Physics.
,, Biology.

Geology.
English Composition and Literature.
Design.
Shorthand.
Drawing, Modelling, &c.

The number of subjects taught in the evening classes should be great; such classes should be open to all; in them special fees should be charged; but only a few, say in London 10 or 12, of the larger schools need be used for such evening class centres. For admittance the maximum age might be 15, for attendance 18. The minimum might be about 13. After 18, the classes of such excellent institutions as the Polytechnic or the Birkbeck would be available, or the evening classes of our two or three metropolitan colleges.

The gist of my suggestion is obviously this: Let the number of the compulsory subjects be extended. Let the parent of each child be assured that it will have an opportunity of learning. Not only of gathering information, but of acquiring knowlege.

To this proposal two objections will be raised. (1) That the subjects are too numerous; the child's brain cannot stand so much. (2) The ratepayers' purse cannot stand it. He, the ratepayer, objects to paying for a high-class education for other people's children. To the first of these my answer is that variety in subjects gives relief rather than burden to the child's mind. As a child will be starved if fed exclusively on bread, or cheese, or meat, or fruit, or milk, yet will thrive on a mixed diet of these; so will it thrive intellectually if its intellectual food is varied.

With regard to the ratepayer, I suppose all in this room are ratepayers, and our sympathies are all on his side. But expenditure is one thing, extravagance is another. It is certainly no more expensive and it is far less extravagant to give a varied education than a monotonous one. To grudge variety is as though one were to let a child go into the hedge-rows to gather a handful of wild flowers, and grumble because besides daisies and buttercups and dandelions it had gathered a few violets and primroses.

If you have a school of 600 children, and limit the number in each class to 20, it is clear that if the classes are to be kept at work you must have twenty teachers. It can make no difference in the expense whether these teachers are all teaching different things or all teaching the same thing.

It is clear to me that as long as the Board schools are so constituted that it is a matter of chance to the child whether it has an opportunity of learning anything beyond reading, writing, and arithmetic, and a little history, so long will such schools fail in their purpose. For that purpose is to provide a sound general basis of education, such as will enable the lad, by attending evening classes or by self-culture, to attain the highest happiness of being useful. By all means let us stop wasteful expenditure; but let us as ratepayers not forget that in this matter there is nothing so profligate as parsimony.

If Board schools provided as excellent an education as could be got anywhere else—and this could be done with but little additional expense—the richer ratepayer, of moderate means, who now sends his children to private schools in London or the country, would avail himself of the educational opportunities of the Board schools, and save more in school fees than he disbursed in extra rates.

For £20,000, the Board Schools of London could be equipped with the means of teaching the elements of the more universal of the sciences, such as chemistry and physics.

For £5,000 a year such instruction could be maintained and improved. I believe as much as £70,000 has been given for a picture which can have a really educational effect on not more than a few score of persons yearly. I believe £500,000 is a fair price for a war-ship which may be out of date before being launched, and which may last in a state of efficiency for twenty years.

It is not for me to criticise, even by way of comparison, the sums spent on our armaments. It comes, however, to this, that if the resources of the country are exhausted by the supply of such armaments, so that its social and intellectual states are unnourished, the nation will become like a crab out of season, all shell and claws, with no meat worth defence.

I submit that the School Board curriculum should be altered in the following directions:—

(1.) Drawing (free-hand) should be advanced to an earlier stage, and be far more prevalent in all stages. Writing should be regarded as one kind of drawing, and drawing should precede writing.

(2.) Reading lessons might well be from books treating of natural history rather than of national history, which is for the most part, and in spite of the efforts of a few enlightened men, an account of "events which never took place, and about which nobody ought to care whether they did or not; written by mendacious owls for the benefit of prejudiced bats."

(3.) The teaching of geometry (not Euclid) should be encouraged and made an early subject.

(4.) The teaching of chemistry and physics, but especially of the former, should be far more emphasised.

(5.) The teaching of object lessons in Standards V. and VI. These object lessons are quite of a different kind from those in the infant schools. In the infant schools I would give information about all sorts of things. It does not much matter what the things are so that they are common. The object lessons of Standards V. and VI. I would make strictly systematic, in a fashion which I think is to some extent new, and after a method the description of which will form the bulk of my next lecture.

(6.) The main feature of my suggestions lies, however, in this; that a very much greater number of subjects should be made compulsory, and that, therefore, all such subjects should be taught in all Board schools, and in all schools recognised as giving equivalent education. It is, indeed, with the voluntary schools, or private enterprise schools, that the main difficulty will be found in effecting this inevitable change. All our children ought to be so far watched over by the State, that just as bodily starvation is, according to our Poor-laws, theoretically illegal, so should be educational starvation. The head master of of the most fashionable public school has no more right to feed his boys mainly on Latin verses than had Mr. Squeers to rely on his neighbours' turnip fields.

All arbitrary information excepting that which lies at the root of things, such as the alphabet, should be deferred, in order to give place to the knowledge which is at the root of everything; in other words, the reasoning faculty should be more cultivated, and that of memory less. We should then see, not only the bookbinder's apprentice become the leading light in science, not only the miner become the greatest engineer, but we should find the lowest hind become the most honoured agriculturist, the largest land administrator. The occupation, indeed, of a farm labourer is one requiring perhaps more knowledge and intelligence than any other handicraft whatever. But the knowledge he requires has to be gathered through experience only while his body is overwrought with labour. To him elemetary science would be a boon indeed. That science will have to be given to him in the Board schools or in their equivalents; otherwise such schools will cease to exist.

It is disastrous folly to fight against the inevitable. Science will take, and is taking, its proper place in our system of education. Men may bury themselves in the darkest crypts of ignorance; they may raise the densest smoke of prejudice or spread most diligently their little umbrellas of effeminacy, and fancy they have shut out the sun from the whole earth. The contest, if contest it can be called, which is waged against science, consists of hysterical vituperation on the one hand, and mainly pity on the other. Such a contest is only of passing interest, for the issue admits of no doubt. On the side of our opponents there are, it is true, the prejudices and ignorances of the half-cultured; but on the other there is the whole universe. They who oppose the introduction of science into even elementary schools do so at their proper peril and that of the commonwealth. For in the troublous times which are near, which are at our very doors, the development of scientific knowledge will assuredly prove the sacred ark of our social and intellectual salvation; the star and the column of fire which will lead us out of the wilderness of our perplexities into the promised land of peace and prosperity.

Miscellaneous.

COLONIAL AND INDIAN EXHIBITION.

OPENING CEREMONY.

The ceremonial to be observed on the occasion of the opening of the Exhibition by Her Majesty the Queen, on Tuesday, the 4th of May, will be based on that which was followed at the opening of the Great Exhibition of 1851.

Her Majesty will enter the Exhibition by the principal entrance, Exhibition-road. The Royal procession will then be formed, and will proceed halfway down the Indian Gallery, and turning off to the right by the elaborately carved Indian pigeon-house (which will doubtless prove a useful landmark during the Exhibition) will pass between Old London and the Indian Palace, up the Central Avenue, between the Australasian Courts, across the Canadian Gallery into the gardens, and will then proceed along a broad covered pathway to the Conservatory, and thence into the Royal Albert Hall, where the ceremony itself will take place.

As it would be manifestly impossible for the Queen to walk through all the courts of the Exhibition, it was decided that Her Majesty should, on her progress through the buildings, pass between her subjects from the Colonies; and for this purpose banks of seats, arranged at intervals along the route, have been provided for Colonial visitors. In addition to these, a large number of chairs, lining the pathway on either side, will be placed at the disposal of the public; but the front row will in all cases be reserved for ladies.

The doors will be open at 9.30 and will be closed punctually at 11.0 a.m., after which hour there will be no admission until 4.0 p.m. (when the general public will be admitted, in the usual way, on payment of one shilling each, or by combined railway and other tickets).

Admission to the building to witness the Royal procession will be either by season ticket, purchased before the day, or on payment of one sovereign at the doors. The entrances available will be the India Museum and School of Needlework entrances in Exhibition-road; and the Upper and Lower entrances in Queen's-gate. The principal entrance will be used only by those taking part in the procession.

Admission to the Royal Albert Hall to witness the ceremony will be by special ticket, purchased before the day of opening, to be obtained only at the box-office, Royal Albert Hall, the season ticket office, at the principal entrance of the Exhibition, and the City-office, 96, London-wall, E.C., where the prices and all information can be obtained. The doors of the Hall on the east and west side (the Royal entrance will not be available) will be open at 10.30 and closed at 11.30 a.m.

Season Tickets.

At the last two Exhibitions, the price of the season tickets has been one guinea. This year—taking into consideration the fact that a season ticket holder is enabled to witness the Royal procession on the 4th May, when the price of admission is one sovereign—it has been decided to make the price two sovereigns. Double season tickets have also been issued, giving admission to the owner and one other person, who, however, will not be admitted unless accompanied by the owner. The owner of a double season ticket, moreover, may not introduce a second person whilst another person admitted by it is in the Exhibition. Both double and single season tickets are available for admission to the Exhibition every week-day from 10 a.m. to 10 p.m., except on two Wednesdays and two Fridays (which will be duly announced in the public journals), when they will not be available after 6 p.m. The Royal Commission reserves to itself the right of excluding from the Royal Albert Hall, when it thinks fit, season ticket holders and other visitors to the Exhibition.

AFRICAN COLONIES.

As the Australasian colonies have been grouped together in the central courts of the Exhibition, so have all the British possessions on the continent of Africa been placed in the Queen's-gate Annexe—one of the finest Courts in the Exhibition, 360 ft. in length and 100 ft. wide—through which visitors enter the Exhibition from Queen's-gate. The southern half has been devoted to the Cape of Good Hope, and the northern to Natal and West Africa. Mauritius and St. Helena have been placed in the East Arcade.

Cape of Good Hope.

The Agent-General, Sir Charles Mills, K.C.M.G., who is supported by a committee of gentlemen experienced in Cape affairs, has hitherto represented the Colony in London. He organised the representation of the Cape, and is Acting Executive Commissioner, pending the arrival of the Executive Commissioner, the Honourable J. G. Sprigg, M.L.A. Mr. Sydney Cowper, the secretary, is now busily engaged in the arrangement of the court. While at the Cape he acted as secretary to the Central Committee, composed of twenty-five experienced members, and to several of the sub-committees into which it was divided—committees for wines; woods and vegetable products; cereals and tobaccos; wool, feathers, and animal products; minerals, with a Kimberley local committee; zoology; ethnology; botany; the fine arts; furniture, &c. The mere mention of these committees will show what a varied collection of objects may be expected.

As a preliminary step to the formation of a collection to represent the Cape in London, a South African Exhibition was held last Christmas at Port Elizabeth, under the presidency of the Governor, His Excellency Sir Hercules Robinson, in which Natal, the Orange Free State and the Transvaal also took part. Special endeavours were made that the pastoral and agricultural aspect of the colony should be well represented in London.

There will be skins of sheep and goats and other animals, ox-hides, wools, and Angora hair; horns of various beasts, heads of elephants and other big game, and of horned cattle; sjambok whips made from rhinoceros hide; leathers; a Cape cart and a model of a buck-waggon.

There will be a fine collection of cereals—wheat, barley, rye; and tobacco and silks; and the wines will be duly brought under notice. One of the most important industries of the Cape, ostrich farming, will be represented by stuffed ostriches, and by a trophy of ostrich feathers in their natural state as well as dressed; and the process of dressing will be shown in actual operation. But the diamond exhibit will probably prove to be the chief feature in the court. There will be a large model of one of the famous Kimberley mines, showing the diggers at work; the blue ground (which has been procured from Kimberley for the purpose) will be washed in order to find the diamonds hidden in it, so that visitors may become acquainted with the actual operation. The stones will then be transferred to the hands of the diamond cutters and polishers, who will perfect the operation before the public, much in the same way as the manufacture of watches was last year shown by the Waltham Watch Factory. There will also be a valuable collection of diamonds It may be here mentioned that the value of diamonds exported from the Cape in 1884 was nearly £3,000,000. Amongst the minerals will be shown examples of copper from Namaqualand, of coal (the mining of which is of recent origin), and of crocidolite, which is found in various localities in Griqualand West, and is used for ornamental purposes.

The woods of the colony will be well represented articles of furniture will be shown, made by the natives of the Grahamstown and Lovedale Institutions, of stink wood, iron wood and yellow wood; and a handsome pair of iron gates, wrought at Port Elizabeth, will also be shown. A collection of Bushmen antiquities, with arrow and spear heads of great age and very curious pictures on stone, will prove of interest.

The court will be hung with a carefully-prepared map of the colony, thirty-five feet long, and with paintings and photographs of views and flowers; and, opening out of it, will be a conservatory containing rare orchids and other plants. In the upper gardens will be seen Kafir huts inhabited by natives, who will also carry on their work of basket-weaving, &c., in the court.

NATAL.

Natal has been appropriately placed next to the Cape of Good Hope. His Excellency the Governor, Sir Henry Bulwer, G.C.M.G., is President of the Commission in Pietermaritzburg, of which the Chairman is the Honourable Lieutenant-Colonel Sir Charles Mitchell, R.M., K.C.M.G. The commission numbers amongst its members the Secretary for Native Affairs, the Colonial Engineer, the Speaker of the Legislative Council, Sir Theophilus Shepstone, and the Mayors of Pietermaritzburg and Durban. District Commissioners were also appointed to look after the different divisions of the colony. The Executive Commissioner in London, Sir William Sargeaunt, K.C.M.G., is assisted by a committee of gentlemen, familiar with affairs of the colony, suggested by the Natal Government. The chief industrial products of the colony will be very well represented. Fine specimens of sugar, coffee, tea, grain, wool, pottery, woods and tobacco will be shown. The special use of some of the native woods, as in the construction of the various parts of the Cape waggon, will be illustrated. Attention will be drawn to the marble of the colony, and especially to the coal, which is found in excellent quality and in large abundance in the Newcastle district, The engineers of the Natal Government railways will exhibit a boiler, a steam whistle, an axle-box, and other articles. Arrangements are in progress for showing some of the most interesting of the vegetable products in a growing state, in a carefully constructed conservatory.

WEST AFRICAN COLONIES.

The West African Colonies—comprising the West Africa Settlements (Sierra Leone and the Gambia), the Gold Coast and Lagos—have for their Executive Commissioner Sir James Marshall, assisted by an influential committee, under the chairmanship of Lord Aberdare, and with Mr. Kenric B. Murray (Secretary of the London Chamber of Commerce) as Secretary. In Sierra Leone there is a committee at Freetown, and various district committees. For the Gambia, His Excellency C. A. Moloney, C.M.G., Administrator, presided over a Commission at Bathurst, previous to his promotion to the Governorship of Lagos. For the Gold Coast are two committees, one of Englishmen and the other of native chiefs; and Lagos also has its local committee.

The Gambia.—The Gambia Settlement will contribute large and varied assortment of oils, nuts, seeds, roots, medical plants, fibre, rope, indigo, rubber, gums and bees-wax. The late Governor, Captain Moloney, has sent an excellent collection of butterflies, birds, and shells. There will be silver rings and other native ornaments, native *pangs* or cloths, leather shoes, leggings, purses, &c.; canoe models, sticks, boxes, stools, sofas and chairs; earthenware, grass-work, mats, baskets, hats, bee-hives, and a model of a native hut, with farming implements, swords, and musical instruments. The animal life will be represented by monkeys' heads, a boar's head, horns, an alligator, deer skins, ivory, ostrich feathers, and fish in spirits.

Gold Coast.—The principal exhibits from the Gold Coast will comprise gold ornaments, paid by the King of Ashanti, in 1874, as a portion of the indemnity demanded after the war; also gold beads, ornaments, combs, chains, nuggets, aggrey beads, &c., exhibited by native chiefs and inhabitants; and a large collection of jewellery of native workmanship, lent by private contributors; State chairs and stools of chiefs, native drums and other musical instruments; carved calabashes and ornamented bowls, native cloths made of cotton and silk; native baskets, mats, leather work, earthenware, ivory tusks (carved and plain), monkey and leopard skins, stuffed birds and butterflies; Fetish charms, masks, and images; canoe paddles, and models of canoes; agricultural and gold-digging implements. Palm oils and kernels; rubber; and nuts of various sorts—*e.g.*, tiger, kola, ground and cocoa—will be displayed in the court.

Lagos.—Lagos will contribute a large collection of various specimens of native industry, both from its own neighbourhood and from countries adjacent to the River Niger. Mr. Thompson, who has lately travelled in the Niger countries, has sent some interesting objects collected by him, as well as some photographs of the places he visited. The collections comprise a large number of brass bowls, jugs, pots, leather cushions, sandals, bags and sword sheaths; also specimens of native dresses, cloths and mats, There are an illuminated Koran and other books, as well as native furniture, and wooden images, masks and other rude carvings and specimens of wood. An interesting collection of figures and other objects connected with fetish worship, and a curious fetish table with two rows of carved figures intended to represent the various kinds of inhabitants, will also be shown in this court.

MAURITIUS.

The Executive Commissioner, Mr. J. A. Despeissis, is assisted in his arrangement of the Mauritius Court by Mr. L. G. Adam and Mr. H. J. Jourdain, the Honorary Commissioners. The Commission at Port Louis is presided over by the Honourable John Fraser, and there is a Sub-Committee in Seychelles.

The principal exhibits in the court will be building stones, lime, timber, fibre, cotton, tobacco, soaps, oils, paper-pulp, india-rubber, rice, wheat, maize, flour, arrowroot, sugar, vanilla, coffee, cocoa, cloves, nutmegs, and chocolate. There will be collections of medicinal drugs and plants, mineral waters and cinchonas. The ethnology of the island will be represented; and there will be stuffed specimens of the animals and birds, supplemented by ostrich feathers, ostrich eggs, tortoise shells, and coral. The court will be decorated with oil paintings, water-colour drawings, and photographs of views in the colony; as well as with maps and plans.

The products of the Seychelles will also be shown.

ST. HELENA.

For the purposes of this Exhibition, Ascension and Tristan d'Acunha have been associated with St. Helena. Their Executive Commissioner is Lieutenant-Colonel Edmund Palmer. Although these small dependencies of Great Britain are comparatively unimportant in a productive sense, yet their representation, even on a small scale, conduces to the completeness of the Exhibition as a record of the British Empire.

The principal exhibits from St. Helena will comprise a series of charts and plans from the year 1643 to the present time; books and newspapers published on the island; views and photographs; drawings of plants and other objects; ornaments made from Aloe fibre; fancy articles from indigeneous woods; specimens of the island products; relics of the Emperor Napoleon; and specimens of lavas and rocks.

Ascension will contribute charts and views of the island, lavas, rocks and natural products.

Tristan d'Acunha will be represented by enlarged views of the Tristan group from the *Challenger* expedition, and sections of the bed of the South Atlantic Ocean.

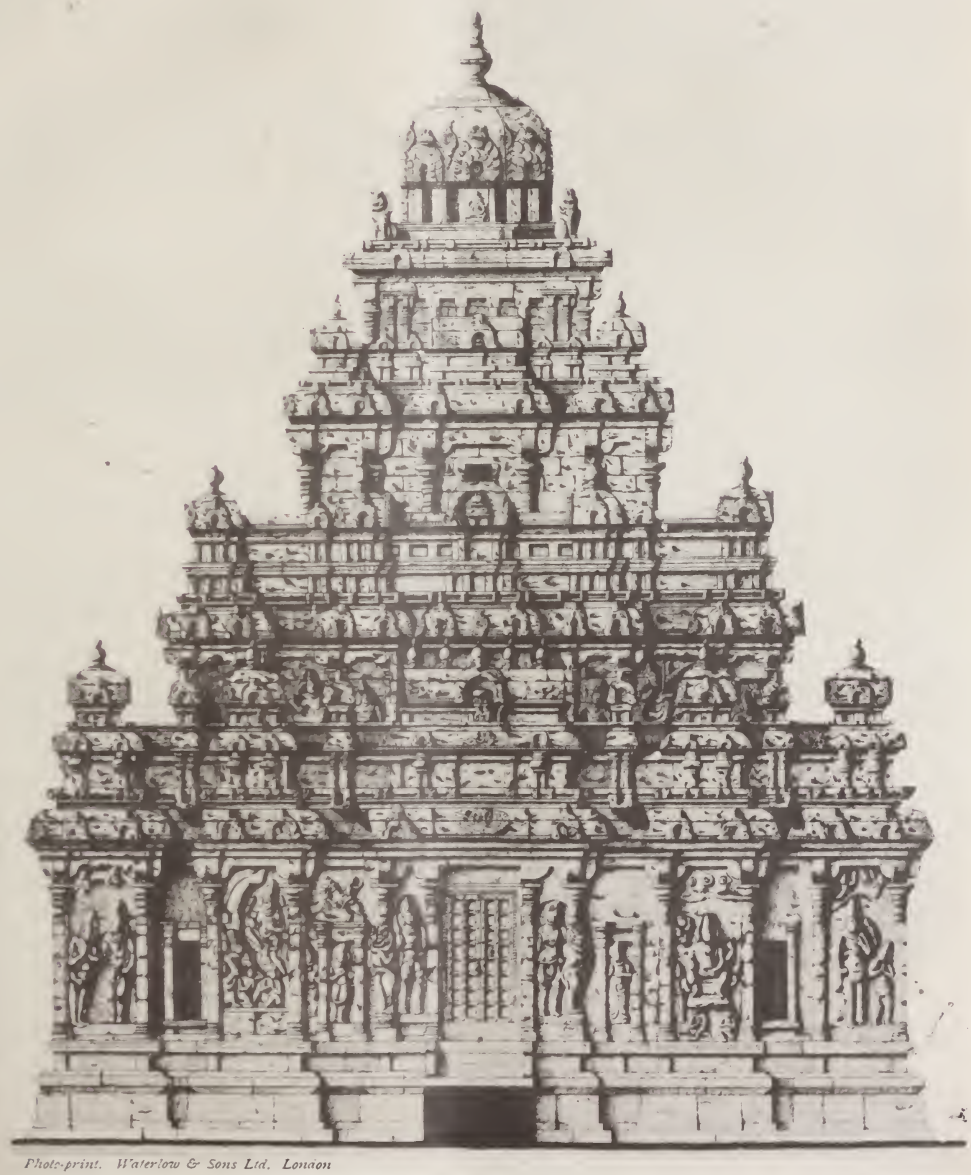
Obituary.

SAMPSON LOW.—On Monday, 12th inst., Mr. Sampson Low, founder of the well-known publishing house of Sampson Low, Marston, Searle, and Rivington, of Fleet-street, died at his house in Mecklenburgh-square, aged eighty-nine. Mr. Low was the son of a printer in Soho, of the same name, whose editions of the classics were admired for their careful printing and elegant typography. He began life as a bookseller and librarian in Lamb's Conduit-street, but afterwards, removing to Ludgate-hill, he established a publishing business which steadily increased. In 1837, he founded the *Publishers' Circular*, a fortnightly trade journal, whose printed list of new books have from time to time furnished the basis of the British and English Catalogues. Mr. Low was elected a member of the Society of Arts in 1862.

General Notes.

COAL IN TRANSYLVANIA.—The *Montan und metallindustrie Zeitung* announces the discovery of an important coal field in Transylvania, near Petrosseny. Its extent, as far as has yet been ascertained, is about 78 square kilometres, and the average thickness of the coal seam is 10 metres (33 feet). The quality appears to be good for gas-making and coke. It is anticipated that when coal mining is carried on in this district, the price of fuel at Petrosseny will be 16 frs. only per ton, instead of 36 frs. as at present.

RECLAMATION OF LAND IN RUSSIA.—Large works for the reclamation of land have been carried out for some years on a large scale in Russia—viz., the drainage of marshes of Pinsk, on the frontier of Russian Poland, a tract of country larger than Ireland. This undertaking was commenced by the Government in 1870, and now 1,620,000 hectares (4,003,246 acres) of land has been reclaimed by the construction of embankments and navigable canals. Of this area, 240,000 hectares (593,074 acres) are excellent meadow lands; 365,000 hectares (901,966 acres) of woods, which, by a rational system of cultivation, are now productive; 202,000 hectares (499,179 acres) of forests, which previously were inaccessible, but are now, thanks to a system of navigable canals, in communication with large towns; finally 813,000 hectares (2,009,036 acres) of good arable land, of which as yet only 50,000 hectares (123,557 acres) is under cultivation. In addition to a large number of miles of canal, and drains, and embankments, it was necessary to construct 179 bridges, and to sink 572 wells, varying in depth from 6 to 25 metres.



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SCALE OF 10 5 10 20 30 FEET

KAÑCHIPŪRAM. VAIKUṆṬHA PERUMAL TEMPLE.

FRONT ELEVATION.

Journal of the Society of Arts.

No. 1,745. Vol. XXXIV.

FRIDAY, APRIL 30, 1886.

All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

NOTICES.

JAPANESE EXHIBITION.

On Tuesday next, May 4th, there will be opened in the Library of the Society, an Exhibition of an extensive series of works of art by the great Japanese masters, ranging from the 9th century to the present date. This exhibition will represent the whole range of Japanese art by specimens of its most famous craftsmen and artists; the objects are kindly lent by Mr. Ernest Hart for the purpose of illustrating the lectures on "The Historic Arts of Japan," which he will deliver on May 4th, 11th, and 18th. The hanging pictures, or *kakemonos*, include specimens of all the great masters, beginning with the works of Kanaoka, the great Buddhist painter of the 9th century, and including brilliant and authentic examples of the pictures of Kano Masanobu and Montonobu, of Sesshiu, Doan, Ritzouo, Moronobu, Matahei, Tanyu, Okio, Korin, Sosen, Mitsunobu, Hokusai, Hoyen, and other of the old masters of pictorial art in Japan.

Among the original drawings are a series of forty by Hokusai, which are the only extant series of original drawings of this great master, and the recent discovery of which has excited great interest in the art world; as well as specimens of the early block printings and hand-coloured sketch books and *sourimonos* of the famous Japanese school of chromo-xylographists.

The wood-carvings include reproductions by Ritsouo, in the 17th century, of the famous temple guardians (Nio) of Nara of the 6th century, and other characteristic specimens of the Buddhist sculpture and portrait statuettes of old Japan.

The metal work will be illustrated by a complete suit of hammered iron armour in *repoussé* by Milochin, of the 11th century, with helmets and smaller decorative pieces of the *repoussé* hammered iron of the illustrious masters.

A collection of some hundreds of sword guards (itsubas), including examples of Metada, Nabouyé, Kinaiye, Kinai, Somin, the Gotos, and nearly all the other famous workers in this peculiarly Japanese department of damascened incrusted iron work, and of the *shibuichi*, *shakudo*, and *mokubé* alloys.

The collection of lacquer work includes examples of the early work of Kotetsu and other workers of the 15th and 16th century, and a long series of classified specimens of the various kinds of lac described by Mr. Quin, and due to the schools of Shicunsho Shiomi, Koma, Korin, Kenzan, the Kajokavas, and other historic artists attached to the court of the Taicuns.

The bronzes range from an early date down to the later work of the three great masters of Japan, Tôun, Seimin, and Yoi, who produced their work in the last part of the 18th century. The keramic ware illustrates the whole range of Japanese pottery from the 15th century, including the "cup of Taikosama" from the temple of Hotoji, and specimens of the earliest blue and white porcelain. Portrait statuettes and other specimens of the finest work of Kakiyémon and Kenzan, the founders of the two great schools of Japanese pottery and porcelain, whose works inspired the porcelain makers of Dresden, Chantilly, and our own Staffordshire and Worcestershire fabric, and a range of specimens characteristic of all the different schools of Japanese keramic art, including samples of the monochrome and flambe ware of the real old Satsuma ware, as well as the more characteristic old ivory coloured faience of the private factory of the Prince of Satsuma.

The collection will be arranged by the aid of Mr. T. Hayashi, of Paris, in the order of historic succession, so as to display the characteristic periods in each department, Mr. Hayashi having come to London for the purpose. It will be further illustrated by chromo-lithographic illustrations of many of the pieces from the recent works of Mr. Audsley and Mr. Anderson.

The Exhibition will be open daily from May 4 to May 22. Hours:—10 till 4, and 7.30 till 9.30, Saturdays 10 till 2.

Members can admit their friends by the use of the usual meeting tickets supplied at the commencement of the Session. There will be no restriction on the number of tickets which can be issued by each member.

The syllabus of the first lecture will be found in the usual place at the end of the *Journal*.

Proceedings of the Society.

CANTOR LECTURES.

By Prof. Frederick Guthrie, F.R.S.

Lecture II.—Delivered February 22, 1886.

On Stuffs and Things.

In my last lecture, I discussed briefly the positions which science has held, is holding, and should hold in general education; and I pointed out what I considered to be the dawn of better things. While expressing my conviction that we should have to look to the Board schools of the future for the surest, perhaps the only, means of raising the level of culture in all classes of the community, I showed what I maintained to be the chief defects in the present system of School Board instruction, and I suggested changes.

To-night I propose becoming more specific in my suggestions. I shall consider what I conceive to be the proper way of introducing the child to a knowledge of the material world, and, in doing this, I shall be describing the scope of what I called object lessons in Standards V. and VI. The term "object lesson" might have been a far more useful one in advancing education, if those who introduced it had been aware of the true meaning of the dispute between "Realists" and "Nominalists." I suppose the existence of that dispute itself is now well nigh forgotten; happily so. Many teachers, and more parents, when they put a piece of putty into a child's hand and call it "soft," or a piece of sugar into its mouth and call it "sweet," fancy that they are teaching the child the properties of things. Surely they are teaching rather the meaning of words. For, as I suppose the most dogmatic of cosmologists will concede, matter and its properties existed before even the English language; so the plasticity of clay and the sweetness of sugar existed before the English names for them were used. But to-night I have to be constructive.

In a little book which I published some five years ago, called "The First Book of Knowledge," I drew up a systematic course of object lessons of the kind which I should like to see generally adopted, because I think that, however defective it may be in many respects, it is perhaps the first attempt to direct this kind of education; and I insist that, on this account, it or its method will have to be considered by educationalists. For, after all, it must be conceded that matter, and the properties of matter, play a not unimportant part in the universe in which we happen—at the present moment at least—to be living. And so my task to-night will consist mainly in considering the purpose and use of such a book.

In the first place, it should not be a book of reference; it should not be written and used on the principle of a directory or of a dictionary, or even of a manual of household recipes, which we consult to-day to find out how to make egg sauce, and to-morrow, how to remove ink stains from the fingers.

It must be progressive in order to be educational; it must deal with familiar stuffs and things in such a fashion, and after such an order, that the understanding of one may help in the understanding of those afterwards to be considered.

The diffusion of the appliances of life and comfort is now so general, that the objects familiar to the child of one social rank are almost sure to be familiar—by sight at least—to those of another. There is, therefore, no difficulty in obtaining abundance of examples suitable for all.

The guiding principle should of course be—in such a system as I am about to sketch—that no term should be used unless it is either at once fully explained, or, at least, without reference to that part of the book where an explanation as complete as possible is given.

Now the explanation referred to must often, in its turn, involve knowledge not yet given. Again, as a matter of fact, we cannot instil abstract principles into a young mind. In education at least the apex of the pyramid is above the base. The effort in the opposite direction produces that inverted and unstable pyramid—the prig.

Here my conclusion means this—that such a book should not be considered to have been read once until it has been read at least twice.

Practical teaching, as distinguished from while accompanying exponential, has long been recognised as the backbone of instruction in the arts, in literature, and in some of the sciences. Thus, if you take a baby and lecture to it for fifty years on harmony, melody, counterpoint, or double bass, you will never make a musician of it if you debar it from touching a musical instrument. For success in pictorial art one must handle the brush. Even the linguist has to "make" verses, "do" exercises, "compose" essays, and so on. Nay, the very mathematical student must supplement his oral instruction by the working of "examples" and "deductions." Of course I am not speaking of the great critical authorities in these subjects; they, for the most part, know nothing, can do nothing, and are the very drones in our intellectual hive.

It is remarkable that the sciences which most required practical teaching were the last to receive it. As a rule, even now, a teacher stands before a blackboard and behind a row of bottles and chalks, and talks and mixes, and calls it chemistry, or involves himself in a tangle of wires and brass and ebonite fittings, and calls it electricity.

In the better class of institutions the pupil has laboratory or practical work in chemistry. And I hope the time is no longer distant when a similar necessity will be universally felt in regard to teaching in physics. My own efforts in this latter direction will form the subject of my third lecture. Such necessity is equally urgent in the teaching of such elementary and natural knowledge as we are now about to consider.

On the table before you is a series of familiar "stuffs and things." The total cost, including the packing-box and bottles, may be three or four pounds. This collection was made to illustrate the book of which I have spoken, and it has been on exhibition in the Educational Collection of the Department of Science and Art for the last few years. The collection contains, I believe, all the stuffs and things required in the building of a house and used by its indweller. I need scarcely call the attention of this audience to the discriminatory use here made of the terms "stuffs" and "things." Ice is a "stuff," an icicle is a "thing." Things are made, by nature or by man, of stuffs. I may here explain that in the book I have mentioned I have striven to use the very simplest language. Thus I would prefer to speak of the "tip of a cat's ear" rather than of the "extremity of the feline aural organ." This is a matter of taste, but being English, and addressing the English, I prefer the English language.

It is possible that this simplicity of language may have stood in the way of the more general adoption of the book and its method by teachers who look upon straightforwardness and clearness as "derogatory to the dignity of the instruction to be imparted." That such a book should be imperfect is a matter of necessity. Thus one critic accuses me, justly I believe, and more in pity than in anger, of using the term window-frame instead o window-sash. Another fumes with indignatio because where I am speaking of concrete I d not describe Portland cement. (I wonde whether he knows what the true explanation i of the solidification of that body.) A thir says that the style is childish, and only fit fo good little boys and girls. The adjectiv "good" I felt keenly, and my only balm wa found in the reflexion that my critic was probably some naughty little boy or girl who ha been rashly entrusted for the time with th office inkpot.

There are many processes used in the manufactures which can only be explained by diagrams in lieu of models. These I do not give for I intend the book to be a very cheap one and especially to be in the hands of the pupil as well as in those of the teachers, and b cause several sets of diagrams of some mer are in the market; but chiefly because well-informed teacher can extemporise suc diagrams on the board.

Here I would accentuate the necessity tha the teacher should know his subject. This appears to be a platitude. But there are, an I suppose will be, teachers whose genera attitude may be described as men with a textbook in one hand and some monitory instrument in the other—hearers of lessons. As t such, either educate them or get rid of them The teacher must know not only the subje which forms the nucleus of the instructio but much around and about it. He then ha at his disposal language far more apt to th wants of his class than the language of th book, which must be based on averages.

Now let us build the house. The first stuf is concrete. This is made of lime and pebbles or gravel. To make lime, again, limeston or chalk is required. And to quicken or bur either fuel is necessary. I find it therefore convenient to describe the formation of coal, and to defer the description of the formatio of wood and the growth of plants, and also o the process of combustion, to a later chapter.

After coal, the description of the formation of coke, ashes, cinders, and breeze follows at once; but the complete description of the manufacture of coke is deferred until that of gas is considered.

The pupil is now prepared to understand the action of fire on limestone—the quenching or slacking of quicklime, and the formation of concrete and mortar. A description of the natural formation of clay is followed by an account of the manufacture of bricks, tiles, drain pipes, chimney-pots, &c. Slate finds its proper place hereabouts.

Such stuffs as marble, granite, sandstone, and plaster (stucco) may be now described.

The chief metals used in house construction or in house furniture are iron, lead, zinc, copper, tin, and mercury, and their derivatives, such as brass, zinc-plate, tin-plate, and so on. And, perhaps, the only stuffs still demanding consideration are glass, glue, whitewash, litharge, and putty.

Now all these stuffs should not only be seen, they should be handled by the pupils, and such processes as the slaking of lime, the setting of mortar and of plaster, the baking of clay, and the reduction of some of the metals from their ores, should be shown, as can easily be done by means of the materials and a few pieces of apparatus before you.

It is thus seen that I adopt the plan, which I think is the soundest one, of not attempting to generalise or philosophise until the child has got something to generalise from. But such generalisation must not be delayed too long; for it is of incalculable help to the pupil in his further studies.

Accordingly, I would here or hereabouts introduce him to that truly awful revelation that there are on the earth, as far as we can search; in the earth, as far as we can dig; aye, and throughout the universe as far as we can see, but a limited number of prime stuffs —the elements. To my mind two men are in no sense on the same intellectual level whereof the one can and the other cannot tell you of what elements familiar things consist. The latter may be intelligent, possibly he is well-meaning; intellectually he is a savage. Such savages abound in all strata of our commonwealth. Such savages are dangerous. We must not kill them; we are not even permitted to teach them. Let ut at least catch and civilise their children, both for their own sakes and ours.

When I taught chemistry, a favourite comparison with me—probably a sufficiently backward one now—was the analogy between the elements on the one hand and the letters of the alphabet on the other. The latter, by their different combinations, are able to express the thirty odd thousand words of our language. And as any one in half an hour can construct half a hundred words which have not yet been used in our language; so any chemist in half a year can construct half a hundred "new" bodies, that is, stuffs hitherto unknown. And here I may be allowed to protest against the "ignorant impatience" of long names evinced by the layman in science. The nomenclature of chemistry is by far the most concise and expressive of all scientific nomenclatures; and its symbolisation is comparatively an ideal shorthand. If we hear the expression, "This is the cow with the crumpled horn, that tossed the dog, &c.," we are charmed by the simplicity of the language. There is far greater charm in the word sulphophenylbenzamid; it is far more expressive, and when we see and handle the thing, and test it, we admit that it must have that name and none other. Indeed a chemical name reminds us of the never-sufficiently-to-be-praised-on-account-of-its-simplicity language of the Germans. As for symbolisation—the well known representation by three lines of a soldier, followed by a pig, entering a public house, is lavish in comparison. For the cow we are glad to accept the gracious interpretation of Caldecott.

The conception of the elements is so great that, like the interior of some vast cathedral, its immensity requires time for the development of its impressiveness. When the learner can, for instance, with his mind's eye see carbon in milk, in sugar, in tea, in chalk, and in cheese, in every plant, and every animal, in his own breath, in the air, in a bottle of soda water, and the nucleus of a comet, he will have enough to set him thinking for a time; aye, for a life-time.

A German poet, in describing a supposed soliloquy of Solomon in his old age, puts these words into his mouth:—

> "Thus I learnt how all things round us out of very few arise,
> By the forces which dwell in them; by dead matters' sympathies;
> How the melody of Nature, though her notes are very few,
> By dint of countless combinations, ever rings out something new."

The conception of the elements leads at once to air and that type of chemical uniting called burning. Much time spent in a careful study of fire, flame, and water, would be well spent indeed. Practically, and returning to our scheme, I find it far best for educational purposes to secure such generalisation at about this point. The pupil can now understand something about wood, the last of the stuffs considered in the building of a house.

I do not mean that he can understand either the ultimate cause or even method of growth. I do not know who is to teach him these things, for though there are hundreds who will talk glibly of protoplasm, there is not one who can show it to the pupil, or who has seen it himself. It is the very bogey of biology, and in that capacity it has to bear the shortcomings of others. Still the pupil may understand that wood consists of none other elements than those lying about its roots or wafting amongst its leaves; and he can reconcile with his reason the fact that the fibre, resin, oil, gum, starch, gluten, and so on, are all words of the same alphabet of material nature, all chords on the same harp.

Such knowledge brings us at once to the heating and lighting of the house, and so to the manufacture of charcoal, the formation of peat, and the making of coal gas. The other products, besides gas, of the distillation of coal, may be here considered, as also the origin and burning of tallow, wax, stearine, solid and liquid paraffin, and petroleum, as also of some of the animal and vegetable oils.

The methods of obtaining a light leads to the interesting and instructive subject of matches, and the stuffs of which they are made. Perhaps here the heat produced by friction may be examined, and so a foretaste obtained of the great doctrine of the mutual relationship of the forces, the indestructibility of energy—a doctrine not second in importance to that of the elementary constitution of matter.

Our next chapter might properly include the finishing and furnishing of the house. By finishing I mean such processes as papering, painting, glazing, and varnishing. Furnishing would embrace the origin and manufacture of cotton-thread, flax, linen, hemp, canvas, cane, wool, carpets, oil-cloth, kokernut fibre, mirrors, German silver, silver; the processes of lacquering, plating, and the manufacture of pottery, porcelain, and earthenware.

The next division would concern the person, and would include chapters on clothing, food, washing, writing and reading.

In clothing would have to be described the textile fabrics, skins, tanning, with such adjuncts as pins, needles, combs, and brushes.

Concerning food I should be inclined to confine the instruction to such things as the five B's of food—bread, butter, beef, beer, and bacon—and such as milk, cheese, eggs.

The description of the manufacture of bread should be in a manner an intellectual epic poem. The growing of the wheat, its threshing, winnowing, grinding, bolting; the nature and effect of yeast; the effect of baking; the relationship between the constituents of the wheat and the body. All this, I say, constitutes an epic of infinitely greater beauty, strength, and significance than can be furnished by the sulks of Achilles, the wanderings of the pious Æneas (I wish he had been drowned), the tortures of the *Inferno*, the ravings of Orlando, the childish imagery of Milton, or the dreary paraphrase of Klopstock.

The epic of bread is, and must be, as far above the epic of the poet as is the mere external beauty of a living flower above that of the most elaborate and gorgeous design on the back of a playing card. And I suppose the study of the construction and life of the flower is more elevating than the most subtle game of whist which was ever played.

In the matter of food, again, we have to guard carefully against the dogmatism of the smatterers who talk so glibly of flesh-formers, fat-formers, bone-formers, and so on, as though you had only to eat fat in order to become fat, bone to become bony, flesh to become muscular. There are people whom one may, without offence, call the "prigs" of this particular branch of science, who fancy that Liebig's extract of meat, for instance, is concentrated meat, and that a few grains of it is of the same nutritive value as an ounce of meat. This, I need scarcely say, was not the view of the illustrious author of the extract. He justly looked upon it as a condiment or stimulant. There are those who, by quoting chemical formula, would fondly persuade us that there is as much nourishment in an egg as in a chop. I need scarcely say I do not believe them, for I don't suppose you do. Such people compare the analysis of grain with that of the human body, and tell us to eat pumpernickel, or rye-bread, or brown-bread, or whole-meal bread, or white bread, according to their schools. In order to be consistent they should recommend cannibalism, and preach that—

"The proper nourishment of man is man."

It is true that you cannot get any element out of the food which is not in it. But it by no means follows that you can get out those that are there. The latter depends upon the individual's digestive powers of assimilation and transformation.

The people of whom I am speaking usually write to the papers. One shows how the condition of the working man may be made one of affluence and comfort by living chiefly on dandelions, nettles, and sorrel (with perhaps a pinch of pepper). Another shows how the weight of a pound of steak may be doubled by cutting it up fine and stewing it with sixteen ounces of water. A third demonstrates how essential to the human frame is a certain amount of lime, and deplores the wastefulness of throwing away the shells of oysters, lobsters, and eggs. Yet another of a more synthetic turn of mind is familiar with heat-producers and flesh-formers with carbon, nitrogen, and phosphorus compounds. His knowledge of chemistry enables him to recommend a cheap dish consisting of charcoal, saltpetre, tallow, and glue, flavoured with singed feathers and stirred up with a few matches.

I need not apologise for speaking at some length on this subject. Food is as important to the human being as fuel is to the steam-engine. It was once made a subject of reproach or banter against our nation that we had a hundred religions and only one sauce, while the nation of our critic had only one religion and a hundred sauces. I suppose if this epigram were fairly analysed it might be found to be based upon the fact that our meats had a hundred different flavours, and our hundred religions only one; while the one religion of our critic's countrymen had a hundred different flavours and their hundred meats a single one. For I need not remind you that when and where the cooking has become most elaborate the feeding is at its worst, for instead of depending upon the exquisite flavours of the simply cooked constituents of a meal, a sort of "Ur-wurst," or universal sausage, containing a thousand flavours, and therefore none, is the result. As good wine needs no bush, so good food need little cookery and less sauce.

In the next place should be considered materials used in cleaning, such as soap, soda, hearthstone, sponge, vitriol, emery.

And finally the materials used in writing and in books. The manufacture of paper and of pens, of inks, of pencils, of type, and the rest.

I cannot but think that some such system as I have laid before you this evening will be —will have to be—introduced into elementary education, into the education of our School Boards. Not only that the lads on leaving school may be more useful citizens, but that they may have that knowledge which alone gives happiness, and which never turns to bitterness, or proves to be vain, the knowledge of the ways and the beauties of almighty Nature.

Miscellaneous.

COLONIAL AND INDIAN EXHIBITION.

The Eastern Gallery and Avenue are occupied by the West Indies, British Honduras, the Straits Settlements, British Guiana, and Hong Kong; whilst British North Borneo, Mauritius, St. Helena, and the Falkland Islands find a place in the Eastern Arcade; and Malta and Cyprus share the East Annexe. Of these, the West Indies, British Honduras, and Hong Kong have already been mentioned (*vide ante* p. 550). The following notes concerning the Straits Settlements, British Guiana, British North Borneo, Malta, Cyprus, and the Falkland Islands, complete the preliminary notices of the various courts of the Exhibition.

STRAITS SETTLEMENTS.

The Executive Commissioner in London for the Straits Settlements, with which are incorporated the Malay States under British protection, is Mr. F. A. Swettenham. The Assistant Commissioner, Mr. N. P. Trevenen, was honorary secretary to the Straits Commission at the International Fisheries Exhibition. The Central Commission at Singapore, presided over by the Hon. J. F. Dickson, C.M.G., was divided into sub-committees to prepare representations of the various industries; and there are local committees in Penang and Malacca.

Amongst the objects of interest in the court will be the models of a street in Singapore, a state house of a Malay rajah, and other dwellings, contributed by Mr. W. A. Pickering, C.M.G.; as well as native fishing boats, and a temple; collections of native weapons, including Malay blow-tubes, spears and shields; musical instruments; toys; coins; fish and fishing apparatus; stuffed animals and birds; drugs and medicinal roots; agricultural implements; rattan and Malacca canes; timbers; food products, and tobacco; preserved fruits; sugar and rum; essential oils; and varied selections of articles illustrative of the life of the natives, including the inhabitants of the Cocos or Keeling Islands. Water-colour drawings of scenery and plants will be shown, supplemented by photographs.

A house from Perak, designed by Malays, is now being erected in the upper gardens by Malay carpenters. It will contain neither nail nor screw, nor in fact any metal whatever. The walls are made of split Bertram palm, plaited and coloured, and the roof will be thatched with *atap*, the leaves of the *Nipah* palm.

BRITISH GUIANA.

Mr. G. H. Hawtayne and Mr. B. H. Jones are Executive Commissioners in London; and the Commission at Georgetown is composed of the members of the Royal Agricultural and Commercial Society of British Guiana. One of the principal exhibits will be a varied collection of timbers, some of which are of great beauty, with their names and details of the uses to which they are most suitable. There will also be a collection of fibres, which will, the Commissioners trust, prove the means of opening up a trade with England; medicinal barks, which are found to be very efficacious in the colony, and some of which are incorporated in the British Pharmacopœia; gums, including specimens of *ballata*, a gum very similar in property and for some purposes superior to india-rubber; oils, tonka beans, isinglass, sugars and rums.

There will also be models illustrative of the means of growing and refining sugar, and of the extensive scheme of drainage which the low-lying situation of the colony renders essential. An ethnological collection has been formed by Mr. im Thurn, the author of several works on British Guiana, who was the first to scale the virgin heights of Roraima. Native canoes, cotton hammocks, and other objects will also be placed in the court, which is being decorated, under the personal supervision of Mr. Hawtayne, in peacock blue and buff, with gold stars on the roof, and a frieze of pine-apples along the walls.

In the upper gardens, by the north-west basin, will be erected a native Indian house from British Guiana, in which a party of six aborigines will be seen working. It is a simple structure, consisting of a roof of plaited palm leaves supported on six pillars.

Indian canoes will also be seen on one of the basins in the gardens.

BRITISH NORTH BORNEO.

The Executive Commissioners in London are Sir Rutherford Alcock, K.C.B., Mr. Alfred Dent, and Mr. W. Kidner, F.R.I.B.A. At Sandakan the local commission is presided over by the Honourable W. H. Treacher, the Governor. The trade of British North Borneo, which is confined to Australia, the Straits Settlements, and China, is concerned chiefly in timber. There are no less than seventy-eight known varieties of Borneo forest trees, many of which measure over 100 feet from the first branch to the ground. But examples only will be exhibited of woods that are obtainable in quantities, and which are suitable for trade purposes. There will be sixteen specimens, including those called from their resemblance to those well known woods, Borneo walnut, mahogany, cedar and ironwood. There will also be shown barks, beeswax, edible birds' nests, cocoanuts, fish, oysters, fruit, gutta-percha, india-rubber, tobacco, pearls, sharks' fins, and tortoises, as well as a collection of native weapons and curiosities. A special feature will be samples of gold recently found on the Segama river, in the neighbourhood of which more extensive prospects will be made.

MALTA.

The Maltese Court is under the direction of Sir Victor Houlton, G.C.M.G., the Executive Commissioner, who was for very many years Chief Secretary to the Maltese Government. The principal features will be examples of the three great specialties of the "Fior del Mondo," as the natives love to call their island stoneware, lace and jewellery—supplemented by specimens of wrought iron work, agricultural implements, and agriculture products, and musical instruments. There will be numerous specimens of both black and white lace; and a fine example of the white silk lace of the island, a tunic in which the Prince of Wales's feathers have been deftly woven, will be lent by Lady Brassey. In jewellery there will be many filagree silver ornaments, and a solid silver birdcage, worthy of special note. The stoneware will be represented by jugs, flower vases, and other articles made of the soft stone, which is readily carved.

Amongst the objects recalling the past history of Malta will probably be some of the most interesting exhibits in the court. These will include ten suits of armour of the period of the Knights of St. John of Jerusalem, lent, together with the spears and halberds, by the Maltese Government; and some antique necklaces of the old pearl and gold work, and *gioia*. Amongst other valuable contributions lent by Sir Victor and Lady Houlton, will be a lay figure, with costume, of the Grand Master Philip L'Isle Adam; a beautiful lamp of the celebrated Maestro Lebrun; a cup, and an order-pendant of a Knight of St. John.

In front of the court has been placed a gateway, thirty feet high, of Maltese stone, finely carved from a design based on German Renaissance as found in Heidelberg. Carved by Maltese workmen, under the surveillance of the Hon. E. Galizia, Superintendent of public works in Malta and chairman of the Exhibition Commission at Valetta, it was sent over in numbered pieces, and was erected in about a week without damage or blemish to a single block.

CYPRUS.

A Committee at Nicosia, under the direction of His Excellency, Major-General Sir R. Biddulph, K.C.M.G., organised the representation of the colony, which has been carried out in London by the Executive Commissioner, Mr. Hamilton Lang, and the Assistant Commissioners, Mr. George Gordon Hake and Captain Wisely, R.E.

Amongst the agricultural implements will be a large-sized model exhibiting the field operations adopted in Cyprus for the destruction of locusts, together with full-sized specimens of the apparatus; a native plough, a bullock cart and ox goad, and a threshing board. There will also be examples of silk, cotton, flax, hemp, and wool; wheat, barley, oats, and honey; bricks, tiles, and building stones; leather, tin, copper, and silver ware. The modern, and especially the ancient, pottery of the island will be well represented. Forest products, fruit trees, and sponges will be shown, as well as specimens of dresses and domestic utensils, and a model of a native hut; pictures, photographs, maps, diagrams, and statistical information.

The two chief attractions of the court will be the stall of the silk weavers and the wine bar. At the latter visitors will be able to become acquainted with *Mavro* (a red wine), the *Commanderia* (a sort of sherry), and the famous white wine of Pera.

It is worthy of note that the flags in the court will bear designs taken from the gold coins of the ancient Cypriote kingdoms, dating from about 800 to 500 B.C.

Falkland Islands.

The exhibits from the Falkland Islands, of which the Secretary to the Royal Commission is Executive Commissioner, relate almost entirely to agriculture, sheep farming, and fishing. There will be sheep skins with very long wool, and samples of wool; some rams' heads with long curling horns; samples of tallow, and specimens of the tussac grass, the most useful of the flora of these islands, which are quite destitute of trees. There will also be seal skins and penguins, and a model of a yacht, supplemented by photographs of Stanley, the capital and the seat of the Government where most of the Falkland islanders reside.

A full account of the Opening Ceremony observed on the occasion of the opening of the Exhibition on Tuesday, May 4th, will be given in the next number of the *Journal*.

REPORT ON ACCIDENTS IN MINES.

The final report of her Majesty's Commissioners appointed to inquire into accidents in mines has now been issued as a Blue-book. The report, which occupies 120 pages, is accompanied by minutes of the evidence taken, and numerous appendixes and diagrams. At the end of the report is given a summary of the most important subjects dealt with in the report, and the following are the chief conclusions and recommendations arrived at by the Commissioners:—

1. That it is most important that all mines should be carefully examined by means of indicators capable of detecting as small a proportion as 1 per cent. of gas; such examination to be made before the commencement of each day-shift, and, in case of an interval, also before the succeeding shift. 2. That in all dry mines where the air may be laden with coal-dust, and where fire-damp is either known to be given off from the strata, or may from experience be reasonably suspected to exist, the Secretary of State may require safety-lamps to be used, unless the owners and workmen of such mines prove, to the satisfaction of a court of arbitration to be appointed by the respective parties, that less liability to accidents generally will be involved by the working of the mine with open lights than by the use of safety-lamps. It should be a special instruction to such court that the circumstances of each mine be taken into consideration with reference to the following points:—(*a*), the mode of working; (*b*), the nature of the coal seams and of the roofs and floors of the seams and of the adjacent strata; (*c*), the proximity of the seams to each other; (*d*), the emission of gas from the seam, and the liability to blowers or outbursts of gas from the coal, roof, or floor; (*e*), the order of working the seams of coal. For the system which prevails in some places of working with mixed lights—that is, with open lights and safety-lamps intermixed in the same set of workings—there is no justification, and this practice should be strictly prohibited. We are of opinion that, in mines where safety-lamps are required, the position of lamp stations, or places where open lights are allowed, in reference to the possibility of access of vitiated air, should receive much more attention than at present. It is desirable that, at convenient places near the working faces, reserves of lighted and locked lamps be kept available for exchange with those extinguished in the workings.

It has long been known that if the atmosphere become inflammable, the Davy and Clanny lamps, and in a less degree the Stephenson lamp, are unsafe in currents having velocities much below those encountered in well-ventilated mines. Our experiments fully confirm this. The ordinary Davy lamp becomes unsafe before a velocity of 400 feet per minute is attained. The ordinary Clanny lamp will almost certainly cause an explosion in a current having a velocity of 600 feet per minute. A Stephenson lamp will frequently cause an explosion in a current with a velocity of 800 feet per minute. From the information supplied to us by your Majesty's Inspectors of Mines, and others, currents having velocities of more than 400 feet per minute are now frequently found in working places. The currents sweeping along wall-faces have very often higher velocities; in main air ways current-velocities approaching 2,000 feet per minute are recorded, and considerably higher velocities are encountered at regulators and in narrow places, or when large falls occur. It is thus obvious that, in the present improved ventilation of collieries, ordinary Davy and Clanny lamps have ceased to afford protection from explosion, and that the Stephenson lamp, though more secure than the former, cannot be relied upon. We felt it our duty at an early stage of our investigation to draw the attention of the Secretary of State to the danger attending the use of the ordinary Davy and Clanny lamps, and our subsequent experiments have made this danger still more conspicuous. We have no hesitation in stating that these lamps should be prohibited, unless they are enclosed in cases capable of effectually preventing the gauze from being exposed to the full force of the current of air. Many lamps now exist which are able to resist, in highly explosive atmospheres, current velocities up to and even exceeding 3,000 feet per minute, at all events for several minutes. Ample time is thus obtained for bringing into operation a "shut off" appliance for the extinction of flame produced both by the illuminant and by ignited gas within the lamp. We consider that all safety-lamps should be provided with such an appliance.

Four lamps seem to us deserving of special attention, as combining a high degree of security with fair illuminating power and simplicity of construction. They are Gray's lamp, Marsaut's lamp, the bonneted Mueseler lamp, and Evan Thomas's modification of the bonneted Clanny lamp, described as No. 7 in our report. In our experiments the last lamp has given, upon the whole, the best results. It will be seen, however, from our experiments that many other lamps exist which are simple in construction, and almost, if not quite, as safe as the above. They generally, however, yield an inferior light in consequence of the flame being surrounded by gauze, but from this method of construction they derive the advantage of not being entirely dependent on glass for their security. To make a particular lamp compulsory would be unwise, as calculated to throw difficulties in the way of introducing improvements which will no doubt arise in the future, but we think it desirable that some control should be exercised in reference to the description of lamps employed in coal mines, and that only those lamps should be used which are authorised from time to time by the Secretary of State. A lamp may be of the safest pattern, and yet small defects in the fitting of its parts may entirely deprive it of its power of affording protection. In preparing a large number of lamps for use in a mine it may happen, even with the greatest care on the part of the lamp-men, that a lamp in an imperfect condition may be allowed to pass. The detection of these imperfections by simple inspection is in many cases almost impossible, and we are convinced that the only way of avoiding the introduction into a mine of a dangerously imperfect lamp is to test every lamp in an explosive mixture of air and some inflammable gas before it is allowed to descend the shaft. Though we have good reason to believe that the practice of surreptitiously opening safety-lamps in the workings is much less prevalent than formerly, it is still necessary that such lamps should be locked. We have examined many appliances for this purpose, and we consider that the plan of fastening the oil vessel to the other part of the lamp by a riveted lead plug, impressed at each end with marks or letters varied from time to time, is the simplest, the most efficient, and the one most likely to lead to the detection of any attempt to tamper with the lock. The power and uniformity of illumination given by a lamp can be notably improved by using as the illuminant vegetable or animal oil mixed with about one-half of the volume of a petroleum oil of safe flashing point. The use of petroleum spirit or benzine as the illuminant in safety-lamps, instead of vegetable or animal oil, is attended with some advantage, but it is also liable to introduce new sources of danger. Special care is needed in the filling and trimming of lamps, and in the arrangement of lamp-rooms, to avoid the ignition of the highly explosive mixture formed by air with the vapour arising from this spirit. The selling of petroleum spirit, or of spirit of similar character as to volatility, under designations which are calculated to mislead in regard to the nature of the illuminant, is a proceeding fraught with danger, unless all vessels containing such illuminants bear a prominent label indicating the dangerous nature of their contents. Stringent regulations as to the conditions under which illuminants of this class are to be used and stored are absolutely necessary.

The advantages in point of convenience and efficiency which attend the employment of electric glow-lamps for illuminating the pit's bottom and roadways immediately adjacent to it, have already been demonstrated at several collieries, where this utilisation of the electric light has been combined with illumination at the surface by arc lights. In applying electric glow-lamps to underground illumination to the extent indicated, through the medium of conducting cables leading from the generators to the pit bottom, it is essential to safety, as well as to the permanent efficiency of the installation, that the cables should be placed in positions where they are thoroughly protected against possible accidental injury. It is also essential, in all mines where fire-damp has been known to occur, that the glow-lamps should be excluded from direct contact with the air of the mine in one or other of the ways indicated in this report. Portable, self-contained electric lamps have been devised which will furnish for several successive hours a light considerably superior to that of the best safety-lamps, and which at the expiration of eight hours and upwards will still give a light fully equal to that of a freshly lighted Davy lamp. These lamps are perfectly safe, but as they do not afford any indication of the condition of the atmosphere in a mine, their employment, even if special fire-damp detectors are used, cannot in any case entirely dispense with the necessity for the use of some safety-lamps. For exploring purposes after accidents, or in foul places, these lamps must prove very valuable even in the present condition of their development, and as auxiliary lights they cannot fail to prove very useful. The great progress which has recently been made in the construction of portable electric lamps affords promise of a speedy utilisation of such lamps to an important extent in coal mines. While we think that the safety hooks at present available may have contributed to prevent fatalities from over-winding, we believe that the best appliance for the purpose is an automatic steam brake attached to the winding-gear, and we think it desirable that such brake should be introduced where practicable.

We consider that measures should be adopted to deal more systematically, and if possible more expeditiously, with casualties resulting from the various sources of accidents dealt with in this report. Collieries or mines should be required to provide an ambulance and stretchers for the purpose of conveying to their homes sufferers from injuries received while in the discharge of their duties. Arrangements should be made for the establishment of centres in mining districts, where additional appliances for succour and relief, and also special appliances for exploring purposes, should be maintained in an efficient condition, so as to be ready for use at the shortest notice. It is most desirable that facilities should be afforded for the instruction of men in the use of special auxiliary appliances for exploring purposes, and in simple measures connected with the provisional treatment of injuries. We attach great importance to the systematic inspection of each mine by the workmen, as provided for in the General Rule 30 of the Coal Mines Regulation Act, 1872, and we recommend that this provision should be generally and regularly acted upon.

CONCLUDING OBSERVATIONS.

In submitting to your Majesty the results of our inquiries and experimenial work, and the conclusions to which they had led us, we desire to express our regret at the unavoidable delay which has occurred in the presentation of our report. This delay has been due to the wide range of important and very extensive subjects included in the reference to us, and to the great difficulties we have experienced in bringing to a close the experimental work upon which we have been engaged, almost continuously, since we first entered upon the inquiry intrusted to us. These difficulties have arisen in part out of the constant succession of inventions and suggestions submitted to us in connection with the questions under investigation, many of which demanded careful consideration and necessitated the institution of fresh experiments. They have also been in part due to the circumstances that, as our investigations progressed, the results obtained opened up new fields into which it was necessary to extend our inquiries. In bringing our labours to a termination, we feel very strongly that many of the subjects with which we have dealt need much further elucidation by perseverance in experimental research of the kind which we have pursued. We are convinced that if the work which we are relinquishing were continued, the knowledge of the conditions to be fulfilled for securing safety from preventible disasters, and the development of resources and appliances calculated to promote the fulfilment of those conditions, could still be much advanced. It is, moreover, certain that new subjects for inquiry connected with the safe working of coal mines must continue to present themselves, as has been the case during our seven years' experience. These considerations have impressed upon us the need for the official establishment of some permanent arrangement, by which the continuous pursuit of this highly important class of work would be secured, and by which, also, the merits of suggestions and inventions presenting themselves from time to time would be investigated properly and thoroughly, and dealt with authoritatively. We consider, moreover, that the complete investigation of coal-mine disasters would be greatly promoted if the arrangements to which we have referred were utilised systematically, in connection with the usual official inquiries, in dealing with the difficulties which frequently arise in elucidating the causes of these disasters.

Correspondence.

THE PROPOSED FISHERY BOARD.

I have read with considerable interest Professor Huxley's memorandum on the proposed Fishery Board, and with much of what he says I agree. It seems to me, however, that attention is likely to be diverted from the real question demanding consideration, by Professor Huxley's attack upon certain persons unknown, who appear to have demanded in some newspaper which Professor Huxley has seen, that men of science should "manage the fisheries." That men of science should interfere with commercial speculation, and manage the fisheries in that sense, is a proposition so preposterous, that it is difficult to understand why Professor Huxley should have thought it worthy of notice.

The question which really demands consideration is another one altogether, and is simply this:—Is it desirable that men of science should be definitely and permanently employed to manage the inquiries which are necessary in order that a satisfactory basis may be obtained for legislation in regard to a variety of fishery questions? And further, is it desirable that such persons should be employed by the State in order to ascertain whether certain steps in the way of protection and cultivation of fishes can be usefully carried out by the State for the benefit of the community? Professor Huxley does not, in my judgment, attach sufficient importance to such inquiries and the necessity for a permanent organisation of officials to deal with them when he says, "Let the department obtain such scientific help as is needful from persons of recognised competency, who are not under the control of the administrative department." This proposal seems to be somewhat inconsistent with another statement in the memorandum, where Professor Huxley says, "I should say that any amount of money bestowed upon the scientific investigation of the effect of some modes of fishing might be well spent." If "any amount of money" is to be spent, and so large a question as "the effect of some modes of fishing" is to be investigated scientifically, then it would seem well that the department should have a trained and permanent staff of expert naturalists and a scientific authority to direct their inquiries.

The fact is that enough time and money has been spent by the State upon spasmodic inquiries into the effects of trawling, and the various questions, the rapid investigation of which has from time to time appeared to be "needful." What is now needed is a more systematic and determined attempt to grapple with some of the more important questions, the solution of which is likely to affect the interests of the fish industry.

I have drawn up a brief statement on the subject of the relation of scientific investigation to fishery interests, which, in no dogmatic spirit, but with a view to eliciting criticism and suggestion, I here submit to the reader:—

1. The necessity for an administration of our marine and freshwater fisheries, based upon thorough or scientific knowledge of all that relates to them, has become obvious of late years. The Trawling Commission of 1884-85 has reported to this effect, in so far as the subject of their inquiries is concerned. Other nations have adopted such a method of dealing with their fisheries, with good results and the promise of better.

2. The inquiries and operations necessary cannot be conducted as the result of private commercial enterprise. They must be national in character.

3. Whilst the general trade returns of the fishing industry on the one hand, and the practical enforcing of regulations as to the protection of fishing grounds and the restriction of fishing operations within certain seasons and localities, are matters with which an ordinary staff of officials can effectually deal, yet the chief purposes of the operation of a satisfactory Fisheries Department are of such a nature that only expert naturalists can usefully advise upon them and carry them out. It is, therefore, important that the organisation of a State Fisheries Department should either be primarily under the control of a scientific authority, who should direct the practical agencies as to trade returns and police, or that there should be distinct and parallel branches of the department—the one concerned in scientific questions, the other in collecting trade returns and in directing the fisheries police.

4. It does not appear that there is any ground for supposing that individuals of scientific training are *ipso facto* unfitted for administrative duties, and there would be obvious advantages in placing the operations of a Fisheries Department under one head. Indeed it may be maintained that an education in scientific matters, and capacity for scientific work, is likely to produce a more practical and enterprising director of such a department than could elsewhere be found. It has not been found desirable to place the administration of the important botanical institution at Kew in the hands of a non-scientific director, and there is no obvious reason for avoiding the employment of a scientific staff in the case of a Fisheries Department. It is extremely important, from the point of view of the public welfare, that the State should not set the example of ignoring the value of scientific knowledge and training; whilst it is no less important to avoid the waste of public money which must result from employing officials who are not conversant with the matters with which they have to deal in place of trained experts.

NATURE OF THE WORK TO BE DONE.

1. Generally to ascertain what restrictions or modifications in the proceedings of fishermen are desirable, so as to ensure the largest and most satisfactory returns, prospectively as well as immediately, from the fishing-grounds of the English coast and from English rivers and lakes.

2. Especially to ascertain whether existing fishing-grounds can be improved by the artificial breeding of food-fishes and shell-fish, and to determine the methods of carrying on such breeding, and to put these methods into practice.

3. To find new fishing-grounds.

4. To introduce new fish—either actually new to the locality or new to the consumer.

5. To introduce (if practicable) methods of rearing and fattening marine fish in stock-ponds.

6. To look after the cultivation and supply of bait.

7. To introduce new baits, new methods of fishing, improved nets, improved boats, new methods of transport and of curing.

The work can be divided into two sections. A. Investigation; B. Practical Administration.

A. Investigation.—The inquiries which are necessary in order to effect the purposes indicated above are as follows:—

1. A thorough physical and biological exploration of the British coasts within a certain distance of the shore-line, especially and primarily in the neighbourhood of fishing-grounds. The investigation must include a determination of temperature and currents at various depths, the nature of the bottom, the composition of the sea-water, and the influence of rivers and conformation of coast upon these features. At the same time, the entire range of the fauna and flora must be investigated in relation to small areas, so as to connect the varying living inhabitants of different areas with the varying physical conditions of those areas, and with the varying association of the living inhabitants *inter se*. Only in this way can the relation of food-fishes to the physical conditions of the sea and to their living associates be ascertained, and data furnished for ultimately determining the causes of the local distribution of different kinds of food-fishes, and of the periodic migrations of some kinds of them.

2. A thoroughly detailed and accurate knowledge of the food, habits, and movements of each of the important kinds of food-fishes (of which about five-and-twenty, together with six shell-fish important either as food or bait, may be reckoned). The rela-

tion of each of these kinds of fish to its fishing-ground must be separately ascertained; its time and mode of reproduction, the mode of fertilisation of its eggs, the growth of the embryo, the food and habits of the fry, the enemies of the young and of the adult, the relation of both young and adult to temperature, to influx of fresh water, to sewage contamination, to disturbing agencies such as trawling, and ordinary traffic.

3. An inquiry as to whether over a long period of years there has been an increase or decrease in the abundance of each kind of food-fish on the chief fishing-grounds as a matter of fact, together with an inquiry as to the actual take of each kind of fish in successive years, and, further, an inquiry as to any accompanying variation in (*a*) the number of fishing boats, (*b*) the methods of fishing, (*c*) the climatic conditions, or other such possibly influential conditions as previous inquiry may have suggested.

4. An inquiry for the purpose of ascertaining, experimentally, whether the decrease in the yield of fishing grounds, in regard to each several species of food-fish, can be remedied—(*a*) by artificial breeding of the fish; (*b*) by protecting the young; (*c*) by increasing its natural food; (*d*) by destruction of its enemies; (*e*) by restrictive legislation as to time or place of fishing, and as to size of fish which may be taken, and character of fishing apparatus which may be used.

5. An inquiry to ascertain whether, if periodic, natural causes are at work in determining the fluctuations of the yield of fishing-grounds their effect can be foretold, and whether this effect can in any cases be counteracted; similarly to ascertain in the case of migratory shoal-fish whether any simple and trustworthy means can be brought into operation for the purpose of foretelling the places and times of their migrations, so as to enable both fishermen and fish dealers to be ready for their arrival.

6. An inquiry into the diseases of fish, especially in relation to salmon and other fresh-water fish.

B. Practical Administration.—The chief heads under which this presents itself as distinct from the antecedent search for reliable data are:—

1. The management of an efficient "intelligence department," giving weekly statistics of the fishing industry, the appearance and disappearance of certain fish at particular spots, the number of fishing-boats employed, the methods of fishing employed, the meteorological conditions.

2. The advising and enforcing of restrictions by the Legislature as to time, place, and method of capture of fish.

3. The artificial breeding and rearing of fish to stock impoverished fishing-grounds.

4. The leasing and management of the foreshore and sea-bottom in particular spots, for the purposes of oyster-culture and mussel-culture, and of marshlands near the sea for the formation of tanks and fish-ponds.

5. The opening up of new fishing-grounds and of new fish industries (curing and treatment of fish for commercial purposes).

6. The introduction of new species of food-fish and shell-fish.

GENERAL ORGANISATION AND STAFF NECESSARY TO CARRY ON THE INQUIRIES, AND TO PUT RESULTS ATTAINED INTO PRACTICE.

It is a matter of fundamental importance to determine, first of all, whether it is desirable that these matters should be dealt with by a permanent staff or, on the other hand, by the occasional employment of a scientific man—not habitually occupied in these inquiries—to attempt the solution of any particular problem which an unskilled official may present to him.

Clearly there must be economy in employing permanently certain naturalists who will familiarise themselves with this special class of questions and become experts in all that relates to fishery problems.

Further, is it desirable that the matters which are to be inquired into should be determined by an official unskilled in natural history? Or, on the other hand, that the selection of inquiries likely to lead to a satisfactory result should be made by a man of science, specially conversant with the nature of the things to be dealt with?

The organisation required consists, so far as persons are concerned, of:—

(1.) A chief scientific authority.

(2.) A staff of working naturalist-inspectors.

(3.) A staff of clerks.

And, so far as material is concerned, of:—

(4.) A London office, with collection of fishes, apparatus used in fishing, maps, survey-records, statistical returns, and library.

(5.) A surveying ship, under the orders of the department, to be manned and maintained by the Admiralty.

(6.) A chief laboratory fitted for carrying on investigations such as those named above, and also two smaller movable laboratories, together with steam-yacht fitted for dredging and sounding.

(7.) Hatching-stations and fish-ponds.

With regard to the foregoing headings, it is a matter for consideration whether the "chief scientific authority" should be an individual or a committee of five. The position assigned to this post should be equal to that of the Director of the Geological Survey, or the Director of the Royal Gardens, Kew; or if the "authority" takes the form of a committee, it should be placed on the same footing as the Meteorological Council. The person or persons so appointed should be responsible for all the operations of the department, and of such scientific training and capacity as to be likely to devise the most useful lines of inquiry and administration.

The "naturalist-inspectors" should be six in number, but operations might be commenced with a smaller staff. They should be thoroughly competent observers, and under the direction of the chief scientific authority they would be variously employed, either on the surveying ship, at the chief laboratory, or in local laboratories, hatching stations, or in the London office and museum.

The naturalists thus employed would become specialists in all matters relating to the life-history of fishes and their food; they would acquire a skill and knowledge far beyond that which it is possible to find amongst existing naturalists, who occasionally are requested to make hurried reports on such matters as salmon disease, or the supposed injury of the herring-fisheries by trawlers.

One of the naturalist-inspectors should be a chemist and physicist, in order to report on the composition of the water and the nature of the bottom in the areas investigated.

"Clerks" would be required in the London office to tabulate statistics and carry on correspondence. These gentlemen need not necessarily have any scientific knowledge. It would probably be necessary to have a correspondent or agent of the department in every large fishing centre. Probably the coast-guard officials might be taken into this service.

With regard to material equipment, it appears to be necessary that a Scientific Fisheries Department should have at its London office a museum of fishing apparatus for reference and instruction, and also complete collections illustrative of the fishes, their food, enemies, and other surroundings. In the same building would be exhibited maps showing the distribution and migrations of food-fishes, the coast temperature and its variations, the varying character of the sea-bottom, sea-water, &c.

The surveying ship or ships would be provided by the Admiralty.

A central laboratory is in course of erection upon Plymouth Sound by the Marine Biological Association. Her Majesty's Government has promised to contribute £5,000 and £500 a year to this institution on condition that its resources are available for the purpose here indicated. Certain of the "naturalist-inspectors" (probably three at any one time) would be stationed at the Plymouth laboratory in order to carry on special studies of the development and food of particular species of fish.

The smaller moveable laboratories, steam-yacht, and other appliances would not be costly.

RAY LANKESTER, LL.D., F.R.S.

Obituary.

SIR WILLIAM ROSE ROBINSON, K.C.S.I.—Sir William Robinson died on Tuesday, 27th inst., at his residence in Norfolk-square, Hyde-park. He was] the third son of the late Mr. William Rose Robinson, of Clemiston, Mid Lothian, sometime Sheriff of Lanarkshire, by his marriage with Mary, daughter of Mr. James Douglas, of Orchardton and Almorness, in the stewartry of Kirkcudbright, and was born at Raehill, near Glasgow, in 1822, being educated at Haileybury College, and at Bonn. He entered the Madras Civil Service in 1842, and was for some years second member of the Board of Revenue of Madras. In 1873 he took his seat as a member of the Council of the Government of Madras, and he served as Acting Governor of Madras for a short time in 1875, on the death of Lord Hobart. He was nominated a Companion of the Order of the Star of India, in 1866, and advanced to the dignity of a Knight Commander of that Order in 1876. Sir William Robinson was elected a member of the Society of Arts in 1879. He was a member of the Indian Section Committee, and a constant attendant and occasional chairman of the meetings of that section, in the discussions of which he frequently took a part.

MEETINGS OF THE SOCIETY.

ORDINARY MEETINGS.

Wednesday evenings, at Eight o'clock :—

MAY 5.—Adjourned Discussion on Dr. TIDY'S paper, on "The Treatment of Sewage." Sir FREDERICK ABEL, D.C.L., C.B., F.R.S., will preside.

FOREIGN AND COLONIAL SECTION.

At Eight o'clock :—

THURSDAY, MAY 6. — "The Commerce and Industries of New South Wales." By EDWARD COMBES, C.M.G., President of the Board of Technical Education of New South Wales. Sir HENRY BARKLY, G.C.M.G., K.C.B., F.R S., will preside.

INDIAN SECTION.

Friday evenings, at Eight o'clock :—

MAY 7.—"Indian Manufactures from a Practical Point of View." By B. H. BADEN POWELL, C.I.E. Sir JULIUS DANVERS, K.C.S.I., will preside.

CANTOR LECTURES.

The Sixth Course will be on "Animal Mechanics." By B. W. RICHARDSON, M.A., M.D., F.R.S.

Lecture I.—May 3.—Animal and ordinary Mechanism considered and compared. Design and Material.

ADDITIONAL LECTURES.

The course of Elementary Lectures on "Electricity" will be continued by Professor GEORGE FORBES, on Saturday afternoons, at Three o'clock :—

Lecture III.—May 1.—Magnetism.

A course of three lectures on "Japanese Art Work" will be delivered by ERNEST

HART, on Tuesday evenings, May 4, 11, 18, at Eight o'clock :—

LECTURE I.—MAY 4.

METAL WORK.—Japanese Art, individual—its origins, hieratic or warlike—Early Arms, prehistoric—The Iron Period—Hammered and *Repoussê* Iron Armour and Weapons—List of Miochins, their dates and marks—Works of the Gôtos, their style and signatures—Sword-guards and *appliqués* (Itsuba and Menouki, and Futikashirá)—Celebrated makers and their styles—Images and Mirrors—Altar Vases—Bronze Vases and other domestic decorations—Alloys : methods of working and *patine*—Works of the early masters, and of the bronzists of the 18th century—The Niô of Nara—Portrait statuettes—The history of Japanese Enamels, and popular errors concerning them.

MEETINGS FOR THE ENSUING WEEK.

MONDAY, MAY 3...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. (Cantor Lectures.) Dr. Richardson, "Animal Mechanics." (Lecture I.)

Farmers' Club, Inns of Court Hotel, Holborn, W.C., 4 p.m. Mr. S. B. L. Druce, "County Government."

Royal Institution, Albemarle-street, W., 5 p.m. General Monthly Meeting.

Engineers, Westminster Town-hall, S.W., 7½ p.m. Mr. W. A. Martin, "Induced *versus* Forced Draught for Marine Boilers."

Chemical Industry (London Section), Burlington-house, W., 8 p.m. 1. Mr. A. G. Salamon, "The Purification of Water." 2. Messrs. Macnab and Beckett, "The Treatment of Water for Technical Purposes."

Surveyors, 12, Great George-street, S.W., 8 p.m. Professor W. Fream, "The Geology of the Surface in its Practical Aspects."

Inventors' Institute, 27, Chancery-lane, W.C., 8 p.m. Continued Discussion of the Patent Act, 1883.

British Architects, 9, Conduit-street, W., 8 p.m. Annual General Meeting.

Medical, 11, Chandos-street, W., 8½ p.m.

Victoria Institute, 7, Adelphi-terrace, W.C., 8 p.m.

TUESDAY, MAY 4..SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. (Special Lecture.) Mr. Ernest Hart, "Japanese Art Work." (Lecture I.)

Royal Institution, Albemarle-street, W., 3 p.m. Prof. A. Gamgee, "The Function of Circulation."

Central Chamber of Agriculture (at the HOUSE OF THE SOCIETY OF ARTS), 11 a.m.

Civil Engineers, 25, Great George-street, S.W., 8 p.m. 1. Mr. Francis Fox, "The Mersey Railway." 2. Mr. William Edmund Rich, "The Hydraulic Passenger Lifts at the Underground Stations of the Mersey Railway."

Pathological, 53, Berners-street, Oxford-street, W., 8½ p.m.

Biblical Archæology, 9, Conduit-street, W., 8 p.m.

Zoological, 11, Hanover-square, W., 8½ p.m. 1. The Secretary, "Addition to the Menagerie in April." 2. Mr. W. F. Kirby, "Remarks on four rare Species of *Sphingidæ.*" 3. Mr. Frank E. Beddard, "Observations on the Ovarian Ovum of *Protopterus.*"

Antiquaries, Burlington-house, W., 2 p.m. Annual Meeting.

WEDNESDAY, MAY 5...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. Adjourned Discussion on Dr. C. Meymott Tidy's paper, "The Treatment of Sewage."

Patent Agents, 57, Chancery-lane, W.C., 7½ p.m. 1. Discussion of Mr. A. V. Newton's paper, "Suggestions for Amending the Form of Procedure in Patent Suits." 2. Mr. O. Imray, "Suggestions as to the Maintenance of Permanent Offices and a Library for the Institute."

Entomological, 11, Chandos-street, W., 7 p.m. Mr. T. W. Slater, "The Origin of Colours in Insects."

Archæological Association, 32, Sackville-street, W., 4½ p.m. Annual General Meeting.

Obstetrical, 53, Berners-street, 8 p.m.

Civil and Mechanical Engineers, 7, Westminster-chambers, S.W., 7 p.m. Annual General Meeting.

THURSDAY, MAY 6...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. (Foreign and Colonial Section.) Mr. Edward Coombes, "The Commerce and Industries of New South Wales."

Royal, Burlington-house, W., 4½ p.m.

Linnean, Burlington-house, W., 8 p.m. 1. Sir J. Lubbock, "Seedlings." 2. Mr. G. J. Romanes, "Physiological Selection; an additional suggestion on the origin of species."

Chemical, Burlington-house, W., 8 p.m.

Society for the Encouragement of Fine Arts, 8 p.m. Conversazione, at the Galleries of the Royal Institute of Painters in Water Colours, Piccadilly.

South London Photographic, 1, Adam-street, Adelphi, W.C., 8 p.m.

Royal Institution, Albemarle-street, W., 8 p.m. Prof. Dewar, "The Alkaloid." (Lecture I.)

Mechanical Engineers, 25, Great George-street, Westminster, S.W., 7½ p.m. 1. Mr. J. Alfred Griffiths, "The Distribution of the Wheel Load in Cycles." 2. Mr. Thomas W. Wailes, "The Raising of the Wrecked Steamship, *Peer of the Realm.*" 3. Mr. T. B. Lightfoot, "Refrigerating and Ice-making Machinery and Appliances." 4. Mr. Henry Teague, "Notes on the Pumping Engines at the Lincoln Water Works."

Archæological Institution, 16, New Burlington-street, W., 4 p.m.

East India Association, 14, Bedford-row, W.C., 8 p.m.

FRIDAY, MAY 7 ... SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. (Indian Section.) Mr. B. H. Baden Powell, "Indian Manufactures from a Practical Point of View."

United Service Institute, Whitehall-yard, S.W., 3 p.m.

Royal Institution, Albemarle-street, W., 8 p.m. Weekly Meeting, 9 p.m. Mr. F. Siemens, "Dissociation."

Mechanical Engineers, 25, Great George-street S.W., 3 p.m. Annual Meeting. Reading of Papers and Discussion continued.

Geologists' Association, University College, W.C., 8 p.m. 1. Mr. J. Postlethwaite and Mr. J. G. Goodchild, "Some Tribolites from the Skiddaw Slates." 2. Prof. G. S. Boulger, "The Connections in time of changes in Fossil Floras with those of Faunas."

Philological, University College, W.C., 8 p.m. Mr. A. J. Ellis, "Report on Dialectical Work."

SATURDAY, MAY 8...SOCIETY OF ARTS, John-street, Adelphi, W.C., 3 p.m. (Special Lecture.) Prof. George Forbes, "Electricity." (Lecture IV.)

Physical Science Schools, South Kensington, S.W., 3 p.m. Mr. Shelford Bidwell, "A Modified Form of Wheatstones Rheostat."

Botanic, Inner Circle, Regent's-park, N.W., 3¾ p.m.

Royal Institution, Albemarle-street, W., 8 p.m. Prof. Ernest Pauer, "How to Form a Judgment on Musical Works."

Journal of the Society of Arts.

No. 1,746. Vol. XXXIV.

FRIDAY, MAY 7, 1886.

All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

NOTICES.

CANTOR LECTURES.

Dr. B. W. Richardson, F.R.S., delivered the first lecture of his course on "Animal Mechanics," on Monday evening, 3rd inst , in which he compared animal and ordinary mechanism, showing on the screen, by means of the lantern, a series of figures of the mechanical contrivances of the body.

The lectures will be printed in the *Journal* during the summer recess.

ADDITIONAL LECTURES.

Professor George Forbes resumed his course of elementary lectures on "Electricity" on Saturday afternoon last (May 1st), when his subject was Magnetism. The fourth lecture will be delivered May 8th.

Mr. Ernest Hart delivered the first lecture of his course on "Japanese Art Work," on Tuesday evening, 4th inst., when he dealt with metal work, and drew special attention to the various alloys manufactured by the Japanese. He concluded with a history of Japanese enamels.

The lectures will be printed in the *Journal* during the summer recess.

JAPANESE EXHIBITION.

The Exhibition of Works of Art by the great Japanese masters, ranging from the 7th century to the present date, lent by Mr. Ernest Hart, was opened on Tuesday, May 4th, and will remain open daily until the 22nd inst. Hours: 10 till 4, and 7.30 till 9.30 p.m.; Saturdays 10 till 2.

Members can admit their friends by the use of the usual meeting tickets supplied at the commencement of the Session. There will be no restriction on the number of tickets which can be issued by each member.

Masters and students of schools of art, and the heads of firms of technical art industries (metal-work, carving, pottery, painting, colour-printing, embroidery, &c.), will receive admission for parties on application to the Secretary of the Society of Arts; and, where possible, Mr. Hayashi will endeavour to meet such parties, and to afford special information on any particular questions of technical or art interest.

A classified catalogue of the collection is nearly ready, and will be issued as a supplement to the next number of the *Journal.*

Proceedings of the Society.

CANTOR LECTURES.

By Prof. Frederick Guthrie, F.R.S.

Lecture III.—Delivered March 1st, 1886.

Teaching Physics.

While the several sciences have been so growing in extent that each has put off suckers full of vitality, bonds of interdependence and relationships of common dependence have been established so as to link all the real sciences together into a common system.

Men now living may almost remember the time when mathematics, chemistry, physics, and mechanics were considered as independent sciences. Not assuredly by the greatest masters, but by the general educationalists. The great master is always a poet in the sense of being a metaphysician and a prophet.

It is not my purpose to occupy your time in an attempt to correlate the forces of nature; or to discuss the possibility of their all being modifications of one and the same force. The branches into which physics is still divided for educational purposes indicate something of the history of that collective science, inasmuch as they have reference to our own material organs of perception. Just as our decimal notation in arithmetic refers to our ten fingers so does the fact that we have a separate organ for hearing account for sound being considered for so long a time as a separate force, and being usually treated as a separate chapter of physics, although all admit that sound is in its origin a purely mechanical force of wave-motion.

There is no physical science without exactness, and there is no exactness without measurement. Far as we are still from understanding the mystery of life, it is not to be denied that the greatest advances in biology have been due to exactness in observation and quantitative comparison. This is more markedly the case with the trivial sciences of geology and astronomy. Still more is this to be insisted on in the study of the forces of inanimate nature. I have always, for instance, tried to persuade those of my friends who are engaged in teaching chemistry that they would do well to begin at once with quantitative methods and determinations in the laboratory, synthetic as well as analytic.

It used to be too often the case that a student would be set to work splashing about with a lot of bottles and test-tubes, one eye on them and one on a table of reactions. It would remind one of the finding out an object thought of in the "game of twenty." I believe, as I have always believed, that the making quantitatively of a few preparations, and the carrying out of a few quantitative analyses give more material for thought, more nourishment to the mind, and are educationally of infinitely greater avail than the guessing of chemical conundrums. I am speaking of course of laboratory or practical work. This quantitative element is still more essential in physics. There everything should be quantitative and exact. But there are different degrees of exactness. No one would exact from the average student of chemistry that all his analyses should be of the same degree of refinement as though he were determining the atomic weight of an element. Let his analyses be sufficiently exact to convince him of the faithfulness of nature and the trustworthiness of the statements of the science.

Now, in bringing before you to-night a short account of the system of teaching practical or laboratory physics which has been adopted at the Government Science Schools with which I am connected, I must speak a few words as to the origin of that system. When I joined the service some seventeen years ago it was as lecturer on experimental dhysics at the Royal School of Mines. My duties, like those of my predecessors in the office, consisted in giving about forty lectures in physics. This was supposed to be sufficient physics for the future geologists, miners, and metallurgists. Meanwhile, the encouragement given by the Committee of Council on Education to scientific studies caused such studies to be undertaken in a large and increasing number of schools throughout the country. Put to the test of examination, it appeared that such instruction was very defective, chiefly (speaking of physics) in betraying rather an acquaintance with books than a knowledge of things. Hence it was decided to introduce practical instruction in the teaching of physics of such an elementary, but always exact, kind as would give more reality, vitality, and interest to the instruction, and enable the teachers of science in elementary schools, in their turn, to make the instruction which they gave to their pupils more real and impressive. And as space was found for this purpose at the Science Schools, it was decided that such practical instruction should be given to the School of Mines students. Hence arose the present amalgamated schools.

It will be seen that I advance no claim whatever to the initiative. That merit belongs to those who have had the direction and inspiration of the department in these matters, whom it would not become me even to mention. But this I may claim: the scheme has had from the first my hearty approval.

The problem was briefly this. Given a class of students of various ages, from 16 to 60, and of various degrees of general knowledge and ability. Assume that they are all anxious to learn, and that none of them have worked systematically before in a physical laboratory, and let the instruction be limited to a few months—say four.

The problem is to give them a sound but necessarily elementary training in the science, so that all shall have an opportunity of acquiring such a knowledge of physics as no educated man should be without, and no scientific man dare to be without, and to those who have the ability, the opportunity, and the desire, a trustworthy foundation on which to base their further studies. The scheme must be elastic, so that the same method may be as applicable to sixty as to six.

In the solution of this problem it was my great privilege to have the advice and co-operation of several eminent colleagues. The first difficulty was in finding suitable apparatus Such apparatus as is used for lecture demonstration is for the most part quite unsuitable for the laboratory. Again, instruments of precision, as supplied by the best makers, are too delicate and too expensive to be placed in the hands of an elementary student. For their use there would be required as many skilled assistants as there are students to be taught.

On the other hand, the apparatus sold in the shops for use in elementary instruction is for the most part trash. There are exceptions here and there as to individual pieces of apparatus, but, as a rule, the prevailing sentiment appears to be inspired by the "bag of tricks" of the conjurer. The educational features — the parts involving the principles—are deliberately disguised, and the most highly finished piece of apparatus is supposed to be that which is most thickly smeared with varnish.

The scheme almost necessarily formed itself into the following.— The student attends a lecture every morning, except Saturday, at 10 o'clock. These lectures, in the present case, are about seventy in number. At 11 o'clock he goes into the laboratory, provided with a few tools; there he finds the necessary material for making apparatus relating to the lecture. He has also printed instructions directing him how to make and how to use the apparatus when made. He finds also working models of such apparatus for his guidance. These instructions he carries out under the supervision and advice of a skilled assistant.

As the apparatus so made is frequently and carefully examined and credit given for it, and as the experimental results obtained by its use are noted and receive credit, and as the final practical examination also depends entirely upon the trustworthiness of the apparatus so made, the student soon gets to be exact in his manipulation, and exact in his habits of thought. By this plan the progress of each student in the laboratory is watched, the backward are brought on, while the quicker worker may be allowed to make a few pieces of additional apparatus or more extended experiments. But with such of course he is not credited. As about half the whole credit obtainable is to be got from the written examination, and the other half from laboratory work, and as the laboratory examination may thus be considered chronic, it is not often that a student wholly fails. Rare, indeed, that one fails through want of sufficient ability.

The laboratory work lasts (with an interval) from 11 to 3 or 4 o'clock. As a certain amount of mathematics is essential even in the elementary course, each student on two or three days in the week leaves the laboratory at 3 o'clock for his mathematical instruction. And here let me point out a peculiar general feature of our schools which is, I think, of singular advantage. While the student is learning chemistry, he is learning nothing else, except mathematics and freehand drawing. While he is learning physics, he is learning nothing else but physics, except mathematics and freehand drawing, and so on. I believe that in all higher education this system should be, as far as possible, adopted. Where instruction is attempted by lectures alone, so that a student goes from the Greek lecture room to the physical, thence to the Latin, and so to the mathematical, his mind is only saved from giving way by spinning round, and in his hours of contemplation he asks himself the connection between an aorist and an air-pump, between an eclogue and a naperian log.

It would certainly be a fearful wearisomeness if a student had to listen to and understand four or five lectures on physics every day, even for four months. But laboratory work is not a mentally arduous strain. The hand works, the body moves, the senses are alive. And it is thus that the practical student in science shares fully the pleasure of the artist.

In making the apparatus, the object of course is not to demand from the student, or to give to him, the skill of the artisan. He receives the wood and metal, for instance, cut in pieces of the right size. He must have to acquire a little skill in bending and blowing glass, and in the use of the soldering iron. But what human being should be without this?

The instruments the student of average skill can and does make under proper instruction with these means are far more accurate than those he is at all likely to be able to buy. I do not say that his divided circles will be as accurate as those of Troughton and Sims, nor will his spectroscope compare with one of Hilger's, nor his resistance coils with those of Elliott, nor his barometer with the one at Kew; but I do say that his barometer is a far more exact instrument than one for which he would have to give several pounds; that his spectroscope will divide the sodium line; that his coils are true to the thousandth of their nominal value; that he can determine the wave-length of light to within $\frac{1}{1000}$ of the truth, the specific heat of a metal to $\frac{1}{100}$, and the length of a sound wave to $\frac{1}{200}$ of the truth. The only bought instrument of precision which the student uses in the elementary course is the balance. He has generally, however, acquired some skill with this, and in the manipulation of glass in the chemical laboratory.

The cost of the material for making the apparatus is about £2. The cost of an equally efficient set as bought from a philosophical instrument maker would be not less than £15. Taking the time actually occupied in making the apparatus as two weeks, the wages of a skilled artisan might be £6. Taking plant, supervision, and so on, into account, there is accordingly no unreasonable profit. A perfect physical instrument is priceless. This also is not our business. To us, I mean to the Government, the cost is small (say 30s.). To the student it is nothing. He finds himself at the end of the course with a set of apparatus made by himself, and fully tested by himself; and he finds himself in possession of verifications of many of the great generalisations of physics, which generalisations, having been thus acquired by the simultaneous working of brain and hand, he is slow to forget.

I have here a set of apparatus such as I have described, and such as the students make and use.

Let me briefly sketch the course.

1. By means of this tube which has to be carefully calibrated, we have the student furnishing himself with the means of verifying the connection between the tension or elasticity of a gas, its volume and its density.

2. This syphon barometer has, as you notice, a very perfect vacuum.

3. The methods of determining the specific gravities of solids and liquids I need not describe.

SOUND.

Starting with a tuning fork which is given to him, and the monochord which he makes, the student is able to verify the intervals of the gamut as dependent on length of string. He then examines the effects of variation of diameter, of tension, and of weight of the string.

Tuning forks are, however, seldom exact. The actual pitch of the fork is found by the method of sinuosities, a smoked glass plate is dropped in front of a style on the fork, and so the fork writes its own number. Hence by means of the length of the resonant cavity the velocity of sound in air is obtained with some accuracy, and by the method of longitudinal vibrations the velocity in wood, glass, and brass, &c., follows. The rule of the transverse vibrations of rods is examined. The production of harmonies on strings, rods, and in tubes is shown, and a number of experiments follow concerning the velocity of sound in different gases as determined by dust figures.

HEAT.

Having made and graduated both a direct alcohol and differential air thermometer, the absolute expansions of water and alcohol are determined. Very accurate results may easily be got as to the latent heats of water and steam. Then the student having made his calorimeter, determines the specific heats of iron, copper, zinc, tin and lead. The specific heats of a few liquids are determined both by direct comparison with water or indirectly with the metals.

LIGHT.

In light the chief work consists of the following:—The making and use of the diaphanous and shadow photometers. The making of an instrument for examining the rules of reflection and refraction, and the verification of these rules. The determination of refractive indices of liquids and their dispersive powers. The images from curved mirrors, the measurement of focal lengths, and the curvative and refractive indices of lenses. A few experiments concerning plane polarised light, are followed by the determination of the wave-length by a grating, and the construction and use of the spectroscope.

ELECTRICITY.

The principal pieces of apparatus constructed in this branch are:—A gold leaf electroscope; a differential condenser; a sand-dropping accumulator; a Leyden jar; an electrophorus; a dry pile; a voltaic cell; a differential galvanometer; a resistance bridge; a set of resistance coils; a tangent galvanometer; a potentiometer; a thermo-element; a thermopile. And by these apparatus typical experiments and measurements, of which the following are a few, are made.—The study of magnetic curves; the action of the current on the needle; the relation between length, weight, and resistance in wires; the effect of temperature on resistance; the law of divided circuits; specific resistance; electromotive force; internal resistance of cells, and so on.

Electricity, especially voltaic, lends itself perhaps more abundantly to exact measurements in the elementary laboratory than the other branches, and it is on this account, and because it is the last subject treated of, and so claims any spare time at the end of the term, that it occupies a rather prominent part. I do not hold that it has really any greater educational value than the other branches, and certainly in a general educational course it is not for me to give it prominence, because just now it has a considerable technical development. I trust the time may never come when any branch of physics will be considered as of comparatively little importance in general education. Excepting as to the subjects of mining and metallurgy, our schools are without technical training.

Well, when I first undertook the carrying out of the scheme, the only distrust I had was in my own power and fitness. I had none whatever in the feasibility of the plan. Many told me that it could not succeed, many that it ought not to succeed. As to the last position I am not competent to judge. But to the others, as my answer was then, "I think it will," so it is now, "I think it has." And I say this without hesitation. For as the inception was not mine, so have I been steadfastly supported and encouraged by my official superiors, so have I been loyally assisted by the various members of my staff; and in this respect I should be doing less than the barest justice if I neglected to acknowledge the services of Mr. Boys, to whom I am indebted for a considerable number of new experiments, and for his having recast the syllabus of instruction into its present form.

The Course I. which I have described, having been successfully passed through, a student who wishes to make a special study in physics and take his associateship in that branch has to spend eight months in the laboratory, and have further training in mathematics. During the first four months he exercises himself in certain physical measurements of the most exact character. These students are, under supervision, allowed to use instruments of the highest precision. No hard and fast course is laid down for them, but their work is as much consecutive as possible. In Course III., which is the final, some subject for research is taken up, and though the result may be of a negative character as far as anticipation is concerned, it is a contribution to knowledge, and worth publishing.

I can thus look back with some satisfaction to the success so far achieved, and can look forward with great hope for the future. I find that methods similar to the one I have been describing are growing into use in many places. Not, I am well aware, nearly so much through direct influence from our schools as through the principle—the physical principle—that like force acting on like bodies will produce like effects, or that other one of the political economist, that like wants produce like supplies.

And so, in taking leave of you and thanking you for your patience in listening to me, I would remind you that starting from a review of the present position of science teaching throughout the land, and suggesting various changes in the Board schools, I described a method of interesting and instructing the child in the scientific aspect of nature. To-day I have particularised the method of teaching one branch of science. I have had to use strong language for I feel strongly, and I have been addressing strong people. Of this, at least, you and all men may be well assured that I will not cease to proclaim, as long as strength is given to me, that the hope of science is the hope of the world. That while I yield to none in my love of imagination, of literature, and of all the fine arts, they are as the gracious flowers of the mind-plant whose leaves and roots are the truths of science. True that the living plant is most beautiful when it is in blossom. He who plucks off the flower, while marring the beauty of the plant, destroys the fruit for ever.

TWENTIETH ORDINARY MEETING

Wednesday, May 5, 1886; Sir FREDERICK ABEL, C.B., D.C.L., F.R.S., Chairman of the Council, in the chair.

The following candidates were proposed for election as members of the Society:—

Faren, D. S. M., 47, Holborn-viaduct, E.C.
Gatty, Charles T., 43, Grosvenor-road, S.W.
Harrison, Albert, Thames Sugar Refinery, Silvertown, E.
Hodgkinson, W. R., 29, Pembroke-square, W.
Morris, James Archibald, 16, Adamson-road, South Hampstead, N.W.
Newton, Arthur Henry, Belsize Court, Hampstead, N.W.
Newton, John, Park-green, Macclesfield.
Owen, Richard George, 40, Warwick-road, South Kensington, S.W.
Rathbone, Frederick, Rysel, Rhydal-road, Streatham, S.W.
Wimshurst, James, 4. The Grove, Clapham-common, S.W.

The following candidates were balloted for and duly elected members of the Society:—

Donkin, Edwin Bryan, Southwark-park-road, Bermondsey, S.E.
Douglas, Charles Stewart, Manor-lodge, Sutton, Surrey.
Douglas, William Carstairs, Manor-lodge, Sutton, Surrey.
Fletcher, Alfred E., 57, Gordon-square, W.C.
Leake, Charles Frederick, Hale-house, Staines, Middlesex.
Lockwood, Philip Causton, 1, Gloucester-place, Brighton.
Manchester, Duke of, K.P., Kimbolton, St. Neots, Hunts.
Porter, Edmund Robinson, 16, Daleham-gardens, South Hampstead, N.W.
Quick, Frederick James, New University Club, S.W.
Ripley, Henry, Owston, Doncaster.
Watt, George, M.B., Revenue and Agriculture Department, Calcutta.
Williams, Oliver John, 38, York-road, Lambeth, S.E., and Harwich, Essex.
Wragge, George E., 47, Belvedere-rd., Lambeth, S.E.

The discussion on Dr. C. Meymott Tidy's address on the "Treatment of Sewage," delivered on April 14, took place as follows:—

The CHAIRMAN, in opening the discussion, remarked that since the last meeting, when Dr. Tidy gave such an interesting address on the subject of the treatment of sewage, the report of what he then said had appeared in the *Journal*, and although Dr. Tidy had not had time to correct it, and there might therefore be some slight errors in it, on the whole he believed all would agree that it was a fairly accurate statement of what Dr. Tidy had advanced. He felt that, although it would undoubtedly have been an advantage to have the paper in full, still there was sufficient of the substance of it in print to lead to an interesting discussion. He must inform the meeting that the discussion would have to close that evening, as there was no other available evening to continue it during the present session.

Lieut.-Col. A. S. JONES, V.C., said he had listened last month to Dr. Tidy's extempore address, and regretted to find it reproduced in the *Journal* in the same flowing language, because a condensed digest or summary would probably have been more useful. The author began by saying, "I come here to-night without being an advocate of anybody or anything, and without, as far as I know, having written anything on the subject which can be criticised;" and throughout his paper one was reminded of the expression *qui s'excuse s'accuse*. As to the latter assertion, he (Col. Jones) desired to contrast his own position with that of Dr. Tidy, inasmuch as he had been writing subject to criticism for the last 18 years; and his publisher having asked about a year ago to be allowed to bring out a third edition of an early pamphlet at his own risk, he wrote a short preface on the 18th July, 1885, in which he said:—"Readers will observe that although I put the question 'Will a sewage farm pay?' on the title page I do not even pretend to answer it dogmatically in either the affirmative or the negative; they may draw their own conclusions from the statements which I endeavour to put before them as truthfully as possible, recollecting that circumstances alter cases." Dr. Tidy seemed at last to have come to the conclusion that it was futile to expect to obtain any fixed data in sewage matters from chemical analyses, or from the weighing of human excreta, an operation which he appears to have repeated for his own satisfaction, although he pokes fun at the enthusiasts who have previously founded their theories of the value of sewage on such experiments. For his own part, he thought that almost the only services which the science of chemistry had ever contributed to the cause of sewage disposal were performed long ago, when it showed that sewage sludge had a certain low fertilising value; that the matter held in solution by sewage is five or six times as valuable; and that lime, alumina, iron, and other substances assist in producing more or less deposition of the solids in suspension and solution, when the sewage was allowed a period of rest, or slow motion in tanks, whereby a more or less clarified effluent could be obtained. The chemist in his laboratory called any settlement at the bottom of his test-tubes a precipitate, whether he may have added a re-agent to produce it or not, and the popular distinction between a simple process of deposition by temporary stagnation of sewage and a precipitation process had always appeared unscientific and absurd, although he and others had felt bound to make use of those popular terms as the readiest means of communicating their ideas on the subject. As the author of the paper now under consideration had cleared away some cobwebs spun about the subject by laboratory experiments in decimals of a grain per gallon, perhaps he might be allowed to point out that it would have been a more scientific course, though less attractive to the lay eye, if the comparative analyses between raw sewage and effluents, on which inventors have so often relied, had been based upon the supernatant liquid, after due opportunity had been given for the solids of sewage to reach the bottom of a tank, by the means which nature has provided for the purpose of more or less clarifying all liquids in a state of rest. He (Colonel Jones) had collected so much of the paper as it concerned him to deal with under nine heads, and he was happy to find himself in entire accordance with its author on the first four of that number, which were as follows:—1. Variability of sewage in composition and volume; 2. Necessity for constant attention and cleanliness with the current outlay necessary to secure these essentials. 3. Suspended matter the foulest part of sewage; 4. The advantage of a double treatment by precipitation (in the scientific sense of the word above pointed out), and irrigation; 5. Two insuperable difficulties supposed to attach to the application of raw sewage to land; 6. Frost and heavy rain; 7. The separate system; 8. Ratio of acres to population; 9. Hygiene. It might be convenient to state his opinion, for or against that of Dr. Tidy, on the above points, by grouping 1-4, 5 and 6, and 7-9 as follows:—1-4. As to the variability of sewage, there could be no doubt that it was very great, and he saw no reason, except that of expense, which should have prevented the author taking samples every five minutes consecutively for a year, instead of half hourly for an odd day on three or four occasions, if he wished to get any trustworthy average even for one town. The necessity of constant intelligent superintendence day and night lies at the root of sanitary success in sewage treatment, and the author had done well in calling attention to the carelessness of municipal authorities generally, as to the proper maintenance of a business, for the establishment of which, under pressure, they often voted large sums as capital, with less reluctance than an annual charge, which was equally necessary. But sewage was a disagreeable subject, with which they would fain deal once for all and be done with it, forgetting that they were producing it hourly, and that it would not keep. Here he should like to contribute his testimony to the faithfulness and intelligence shown by the staff of the Native Guano Company at Aylesbury, for he too, like Dr. Tidy, had been a little behind the scenes, having held, for a considerable period, the appointment of engineer for that company's operations with regard to the metropolitan sewage. In the control of such a staff, with the experience gained by Mr. Page and others, he considered that the company held its best asset, and the shareholders deserved great credit and much future success as the due reward of their constancy in upholding the truth—that there was a certain value even in sludge, and that it ought, in some way or other, to be made available in the fertilisation of our fields, as well as the liquid, however much more valuable the latter might be. Having made and sold a great deal of artificial manure compounded from the same basis, he could produce testimonials such as the Native Guano Company does to its value; but, having said this in favour of the company, he regretted to have to add that it made two serious mistakes, one being entirely under its control, although it might not be altogether a free agent with regard to the other, viz., that the price of £3 10s. per ton charged to the farmer is much too high; and, secondly, that the Stock Exchange afforded opportunities for gambling in "Natives." Everyone knew that the suspended matter was the foulest of town sewage—the "crux" of the question, as the Royal Commission under Lord Bramwell called it. Few people now could be found to differ from the opinion that unless an effluent from any kind of precipitation works could be directly discharged into the sea, or a very large estuary, irrigation over land ought to be called in to supplement the clarification of sewage. The author had reserved his opinion upon the new deodorising process recently adopted by the Metropolitan Board as a substitute for the land purification as recommended by the Royal Commission, but he should like to make two remarks on the subject, viz., 1. That land was recommended not only for its oxydising effect on the effluent, but also for its mechanical power of arresting any residue of suspended matter which might escape precipitation under the best system which could be adopted, and that the Board's approval of the system of "starving" down the chemicals to 3·7 grains lime and 1 grain iron per gallon, avowedly with the object of reducing the amount of troublesome sludge rather than that of the saving in cost of chemicals, rendered the land remedy all the more necessary. In fact, that as "separation of the solids," not that of a part of the solids, was recommended, the effluent from such a process would be inadmissible into the estuary even at Hole Haven, for the balance between the total solids in suspension in the sewage plus lime and iron, and the amount of sludge removed, must pass away with the effluent, however "brilliant" the latter might appear to the eye, and there could be no mechanical action in permanganate of soda to replace that of the land. 2. That the deodorisation was temporary in its effect, as anybody might ascertain by keeping a bottle of effluent deodorised by permanganate for a few days, and as the sewage is not supposed to reach the Nore for some six weeks after discharge at Barking, it would seem hardly worth the expense of deodorising it for about one-twentieth part of that period. Passing on to the points on which he differed in opinion with Dr. Tidy (5 and 6), he says that in putting sewage upon land without having first removed its sludge, "two insuperable difficulties occur, and I am now speaking of the results of my own experience on this subject," which is rather at variance with the statement made at an earlier period of the evening. "I do not know myself very much about the agricultural aspect of the subject." Any farmer or labourer even can give the most direct and positive contradiction to the *papier maché* theory. He (Col. Jones) had applied large quantities of raw sewage, sludge, and all, to fallow land every winter for fifteen years, and never found the pores of the soil clogged when it had been ploughed up for roots in the succeeding spring. Frost and heavy rain were also common bugbears with indoor advocates of chemical precipitations, which the farmer knew how to combat without much loss of purification, as percolation went on through the soil all the same under the sheet of ice, and it was quite unnecessary as well as unusual to let the sewage run over frozen ground into a river. (7-9). The separate system had doubtless been ridden too hard by some people as a hobby, but, as in many other practical matters, a happy mean was the best, and he did not think excess of subsoil and surface water would be thought less of an evil by anyone honestly desiring to do his best to clarify sewage by precipitation than by an irrigationist, as implied by the author, might be the case. On the subject of hygiene, he had no hesitation in challenging the author to prove anything supporting his insinuations as to the supposed unhealthiness of sewage farms. In conclusion, he might say a word for the poor farmer, who had often been called conservative where he had only been alive to his own interest. He was at the mercy of the weather in all his operations, but would gladly add the additional care of sewage purification to his other responsibilities, in consideration of its well-known value, but he values his peace of mind too much to put himself at the mercy of soulless Boards, who might at any time employ town-bred chemists and lawyers to effect his ruin at the expense of the ratepayers; and this was the reason why town councils are left to stagger along with their ill-managed farms or precipitation works. Private enterprise succeeds better in all such concerns in England, but mutual confidence between landlord and tenant under such novel conditions must be a plant of slow growth, and the latest revelations of scientific opinions and expert evidence were not encouraging features of the case, as viewed by any enterprising individual or company simply desiring to do the best which could be done for the purification of rivers, and to be judged reasonably in the performance of their duty.

Mr. Baldwin Latham said he should have to differ from Dr. Tidy on some points, but like him, he had no principle to advocate, as he had tried various chemical processes, and had also largely adopted the irrigation plan. The first important point was that of separation; they were told that they were not to separate the rainfall from the sewage; and they were also told that in time of rain the sewers were flushed out, and the consequence was that at that time the sewage was much fouler than at any other time. It seemed to him that that was the very strongest argument for separation. If as much rain as possible were kept out of the sewers, the volume was considerably reduced; if it were not kept out the average daily flow might be increased twenty to thirty times in one hour by a heavy shower. Dr. Tidy said this did not matter to chemical processes, but was of importance in irrigation; he should say on the other hand that it was far more important in a chemical plan, simply because to carry out such a process properly you required large tank space, and if in a limited time thirty times as much rain as the ordinary volume of sewage came down, as the tanks generally held only six hours' sewage, instead of having six hours for precipitation there would only be a few minutes, and the consequence was the sewage must go away in a polluted form. Sufficient tank room could never be supplied (unless the works were on an enormous scale) without the surface water was excluded. He was much surprised to hear Dr. Tidy's remarks on the deleterious effects of irrigation, remembering what he had heard him say, in some inquiries in which he had been concerned. He had himself tried most earnestly to investigate the question of public health and the influence of irrigation farms on the neighbourhoods in which they had been established. He (Mr. Latham) was one of the judges for the Royal Agricultural Society of England in the Sewage Farm Competition, in 1880, and in that capacity had assisted in investigating the condition of health of those living on sewage farms. As to the result, he was quite sure that Dr. Tidy could not produce a number of selected individuals from any part of the country who could compare in health with the inhabitants on the sewage farms. Of course, he did not mean to say that if sewage were badly managed it might not have its evils, or if sewage farms were badly managed or improperly located (and the same with any other sewage works), and a bad effluent got into the water supply, it would not be detrimental to health. On this matter he had looked into the evidence of Dr. Tidy on the Lower Thames Valley inquiry, and he found this question was put to him:—13781. Have you directed your attention to whether any case of disease could be traced to the existence of sewage farms?—A. I have never been able to trace any cases of disease directly to this cause. I have heard a great many reports, and those cases I have had the opportunity of investigating have invariably shown that it was rather a sentimental grievance than any actual cause of complaint." Again, he was asked, at question 13786, if there was any nuisance, and his reply was—"I have never myself seen anything approaching a nuisance, except in evident gross carelessness." He was aware that Dr. Tidy stated in his paper that "consistency was the bugbear of weak minds," and they would probably be satisfied that Dr. Tidy was not of weak mind; but there was a difference between consistency and adherence to truth. Having carefully investigated the health statistics of a large number of sewage farms, and not being able to trace any evil consequences, he had no hesitation in recommending any local authority which could secure land on favourable terms to adopt that process where it could be used. He did not say, however, that that process was the only process available; there were many others, notably the native guano process, which he had himself adopted in certain cases, and had found very satisfactory. It was very desirable in some cases that a chemical process should be adopted, especially in conjunction with irrigation. He did not consider it necessary always to add a chemical process to irrigation, but he thought irrigation to some extent should always follow a chemical process. Dr. Tidy said nothing about artificial filtration, but he had found it necessary to adopt the plan sometimes where it was impossible to obtain land, so as to give a final purification to the sewage after chemical treatment. He approved of the suggestion thrown out by Sir Frederick Abel, Dr. Dupré, and Mr. Dibdin, for using some chemical which should readily part with oxygen, as a final purifier of the effluent, was a good one. With regard to sludge presses, he thought it ought to be known that this was one of the very earliest inventions used, and the press as now used was almost identical with that devised by Mr. Wickstead, at Leicester, where it turned out what were called Leicester bricks. Mr. Wickstead was probably in advance of the present age with regard to the use of these presses, for instead of using compressed air, which was very expensive, he used a column of the liquid sludge, which produced a constant and steady pressure at little cost compared with the use of air. The sludge was constantly pumped into a high column, and came out at the bottom in the solid form. He did not think Dr. Tidy had really done the subject justice in the remarks which he made, and he was extremely anxious to see the figures upon which the observations were based. There was no doubt that he had a vast experience, and had also succeeded a gentleman who had a much larger experience, and together they possessed an enormous mass of material which was of extreme value; and if this were put into the form of a paper, it would be an extremely valuable acquisition to the literature bearing on the question. With regard to the question of London sewage, he had always been of opinion that, owing to the position of London outfalls, it was extremely desirable that a perfect system should be adopted for purifying the sewage, because unless they could really get rid of the sewage out of the river, difficulties would arise very much more serious than were generally supposed. There were a large number of various works upon the sides of the Thames which possessed wells, and in the case of Woolwich Arsenal, it was stated that the well was tidal, so that there appeared to be a direct connection with the Thames itself. That was no doubt also the case with a large number of wells in London, and as the Corporation of London were now proposing to sink wells in the city, in order to furnish a supply of water, as such water came very largely direct from the river, the question of keeping the river pure was of very great importance, and it was imperative that whatever was done with the London sewage, unless it was removed clean out of the river, it should be so treated as to prevent noxious results arising from it.

Mr. PEREGRINE BIRCH said he noticed that Dr. Tidy was unable to understand how Dr. Frankland found that there were 25,000 tons of sludge and sewage matter kept out of sewers in midden towns, and also that the sewage of midden towns was practically as foul as the sewage of water-closet towns. But that was perfectly intelligible, because it depended upon the fact that water-closet towns, besides throwing a large additional amount of solid matter into the sewers, also threw a large amount of additional water into them. With reference to the separate system, Dr. Tidy stated—and he agreed with him—that we must not be phrase worshippers; but he also agreed with Mr. Baldwin Latham, that it would be very dangerous indeed to trust to rain water flushing sewers, and to making the sewers large enough to carry the rain water. In large cities, such as London, it would be very difficult to adopt a separate system, but in rural districts and country towns something approaching the separate system was no doubt the right plan to adopt. As to the difficulty of disposing of the sewage to the farmers, he might say that in some parts of England the voluntary system had been found to be extremely useful; for instance, at Cheltenham, where precipitating tanks had been erected which did not efficiently perform their object, the Town Council had spent several thousand pounds in carrying the sewers further down the valley, and bought two farms of their own, and had made arrangements with the farmers on the route to take the sewage when they wanted it, and when they did not want it it was put upon the land belonging to the corporation. They received from the farmers sums varying from 4s. to 15s. per acre for a dressing. When the farmers did not want the sewage, they irrigated their own grass lands, and the result had been that instead of spending 6d., 9d., or 1s. per head of the population on using the tanks ineffectually, they had got out of the difficulty at the cost of 1½d. per head, paying off at the same time the cost of 300 acres of valuable land, so that at the end of forty or fifty years they would be possessed of a fine estate, instead of having a liability upon them to improperly deal with the sewage at a cost of 1s. or 9d. per head. With regard to the difficulty referred to by Dr. Tidy, that in hot weather the clay cracked, and the sewage went down without being purified, that clearly proved that the clay was not moist enough, and that this difficulty could be obviated by putting more sewage upon the land. Reference was made in the paper as to certain districts not knowing whether the hose and jet system was the best; but, so far as he knew, this method had been abandoned for the last fifteen or twenty years. He thought Dr. Tidy did not properly appreciate the disagreement between the great authorities upon the subject of soil. If Dr. Way was of opinion that a light soil was the best, and Dr. Liebig that a stiff soil was, it was plain that there was scarcely any soil in the world that would not do for the purpose. His own opinion was that if land could be bought at a cheap rate, stiff land was best, but, on the other hand, in suburban districts, where land was difficult to obtain, a more porous soil must be obtained, or chemicals resorted to. He thought Dr. Tidy had not quite correctly read the report of the Royal Commissioners upon river pollution, for he stated that Dr. Frankland had made an experiment upon one cubic foot of earth, and argued that inasmuch as this foot would do so much, consequently six cubic feet, one on top of the other, would do six times that amount of work; but this was not the case. The recommendation was that there should be six feet of filtering medium; and at page 63 of the Blue-book it was stated that the experiment upon which the recommendations were based was made upon a column of soil 15 feet deep. He quite agreed with Dr. Tidy in his remarks upon irrigation, and in thinking that sewage spread over the land formed papier maché, which would prevent the water from percolating; but if this papier maché was broken up the sewage, would readily pass through. Dr. Tidy next pointed out that it was very desirable to avoid the necessity of using steam power, and in that suggestion he quite agreed, though it was quite possible to go too far in that direction. A few weeks ago he had occasion to support a large town in acquiring land for sewage purposes and pumping the sewage 173 feet high, and they showed conclusively that it was cheaper to pump 173 feet high on to land which could be purchased at agricultural price, than to deliver it on to land close by for which a building land price would have to be paid. In all these matters the question which had to be considered was one of expense. In another part of the paper Dr. Tidy stated that proximity to a town was desirable in order that a ready sale of the rank grass for dairy purposes could be secured, but lower down he stated that this grass was unfitted for dairy purposes. The two statements were not consistent, and therefore he supposed there had been some error in the reporting. He agreed with Dr. Tidy in his remarks about the ridiculous statements with regard to precipitation processes, and the absurd value put upon the products. He found from the evidence given in 1880 by the promoters of the A B C Company, that 16 tons of native guano were produced weekly at Aylesbury, which was sold to vine growers in the South of France. Being curious to know what was the composition of this native guano, he turned to the evidence given by Mr. Page, from which he had produced the Table on the wall, which showed at a glance the absurdity of the assertion that native guano is worth £3 10s. a ton:—

Composition and value of the weekly output at Aylesbury, alleged to be worth £3 10s. a ton.

		Per ton.		£	s.	d.
Charcoal......	4 tons. 14 cwt. at	1s.	..	0	4	9
Clay	6 ,, 10 ,, at	1s.	..	0	6	6
Alum	1 ,, 17 ,, at	£2	..	3	14	0
Blood	1 ,,		..	51	14	9
Sewage deposit	2 tons. 18 ,,					
Total, 16 tons........				£56	0	0

He agreed with the conclusion of Dr. Tidy and Professor Dewar that it was a mistake to pour the black liquid which came from the presses back into the sewer. Dr. Tidy had stated that a Bill ought to be passed to keep the sewage out of the river, and in this he agreed, though he thought the Bill should go further, and provide that the sewage should be kept out of cesspools and wells.

Dr. **Percy Frankland** said there were two points upon which he should like to offer a few remarks. With regard to the statement that the intermittent filtration experiments had been conducted upon one cubic foot of earth, he knew that the experiments were made in the first instance with a column of earth 15 feet long, and that the principal experiments were made with cylinders 6 feet long. In these experiments it was found that remarkable results were obtained by filtration through the column of soil, and before the process of nitrification was properly understood, it was considered that the depth of the soil was a very important factor in the purification of sewage. Since that time valuable experiments had been made by Müntz and Schloessing, as well as by Warington, which had proved that nitrification took place within the first few inches of the soil only, and it appeared, therefore, desirable to try whether filters of less depth would not be equally efficient. With regard to the strength of the sewage in midden towns as compared with water-closet towns, he thought that Mr. Birch had very properly explained that it was simply a question of water supply. If you looked at the towns, the sewage of which was compared in order to obtain those averages, you would find that the towns upon the water - closet system had a larger water supply than those upon the midden system. At any rate that was so in the case of the towns compared by the Royal Commission. The average for the water-closet towns was largely obtained from London itself, and the midden towns were principally taken from Lancashire, where the water supply was much smaller per head than in London. No doubt Dr. Tidy had taken up a very safe point of view in stating that precipitation, irrigation, and intermittent filtration, each had their advantages and disadvantages. There was, no doubt, much truth in this statement, and that different processes were suitable for different places, but it should be clearly borne in mind what were the intrinsic capabilities of each process. People who had to select between the competing methods of purification ought to bear in mind what it was possible to accomplish by each process. There could be no doubt that sewage precipitation was adequate for some purposes, but it was an indisputable fact, which should never be lost sight of, that the best known processes of sewage precipitation could not accomplish such purification as it was possible to obtain by the best methods of irrigation and intermittent filtration.

Mr. **Baldwin Latham** asked whether the filters used by Dr. Frankland were true sections of the earth.

Dr. **Percy Frankland** said he believed they were filled with surface soil.

Dr. **Dupre**, F.R.S., said he had listened to the remarks of Dr. Tidy with considerable pleasure, and upon many points he most heartily agreed; and he could only regret that his action was not always equal to his teaching in that room. There were a few points which he should like to mention, and the first was with regard to the difficulty of collecting a sample of sewage, as he felt sure that many of the discrepancies which appeared were caused entirely by the difficulty of getting a sample, and this difficulty was not got over by taking half-hourly samples. In order to get a fair average of the day's sewage, samples should be taken half-hourly in proportion to the quantity of sewage passing in that time, and this should be carried on for a great many days. Every case of sewage treatment should be dealt with upon its own merits, because it was perfectly obvious that, under certain conditions, a degree of purification might be required, which would be totally unnecessary in another case, as a thing which might be no nuisance in a stable would be a serious nuisance in a dwelling-house. It followed from this that it was not fair to conclude that because an effluent was not good enough for one place that it would not be good enough for another place. With regard to the influence of precipitation on sewage, he could not agree with the remarks of Dr. Tidy, for, according to his experience, and after experimenting upon many hundred thousand gallons in all conditions of weather and sewage, he had come to the conclusion that no precipitation process which had been at present brought forward did sensibly more than clarify the sewage. And in this opinion he was borne out by experiments which had been made by Dr. Tidy and Professor Dewar. Supposing it was a question of collecting the sewage of a number of districts into one (which would at once get rid of one of the maxims of Dr. Tidy that every district should deal with its own sewage), and that district was closely surrounded by houses and pleasure gardens resorted to by thousands of people, and the effluent was to be discharged into a river which was used by thousands of pleasure-boats, it surely was not requiring too much that that effluent should be as pure as it could be made. He did not say that the effluent would produce a wide-spread nuisance, but it would produce a very considerable nuisance. In addition to the removal of suspended matter, precipitation did alter the odour of sewage. It followed that if the effluent was to be discharged into such a district as he had described, where it would be a very serious local nuisance, something more than a precipitation process had to be adopted, and he had no doubt that by far the best process to be adopted was some sort of filtration or irrigation. Now, to take the other case, let them take the outfalls down the Thames miles away from dwelling-houses. In the river there was an enormous volume of water, which exceeded the sewage to be discharged more than 200-fold; was it to be supposed that the effluent should be as perfect as it must necessarily be in the other instance? There was a remarkable unanimity on the part of those who had spoken, that the dissolved organic matters, when the sewage was mixed with a certain quantity of water, would disappear rapidly as they became oxidised. He had often thought that a very good thing would be to cultivate the low organisms on a larger scale, and to discharge them with the effluent into the river, as the power which these low organisms had was something remarkable. With regard to the precipitating material which the Metropolitan Board of Works were prepared to recommend for adoption, he might say that, in conjunction with Mr. Dibdin, he had made various experiments in the matter, and found that by using a larger quantity of precipitating matter better results were not obtained. It was preposterous to expend thousands and thousands of pounds for the purpose of making the sewage a trifle more colourless when discharged into the turbid river, and it was preposterous to remove a small additional fraction of organic matter, when everyone agreed that the dissolved organic matter did no harm, as it would disappear without creating a nuisance. He thought very few people had any notion of the quantity of precipitating material necessary for the metropolitan sewage. One grain per gallon added to the London sewage represented ten tons of material per day; the total amount of material used in the A B C process was about five times that of the suspended matter, or from 150 to 200 grains per gallon of London sewage per day, equal to 2,000 tons to be used daily, which came to 5,000 tons of pressed cake, chiefly formed of materials which had been added. What was it added for? Not to produce any real benefit, because when this very process was used, the organic matter was 18·2 in the sewage, whilst in the effluent it was 18·4 grains per gallon. What was the object of adding 2,000 tons of material daily to sewage for the mere trouble of collecting it again and pressing it at a considerable expense. Then there was another question to be considered. All effluent had some offensive smell, particularly in summer, although when it was once mixed with a sufficient quantity of water it soon disappeared. Still, locally it was a nuisance. The Metropolitan Board, chiefly under the advice of their able chemist, Mr. Dibdin, proposed to deodorise by manganate and sulphuric acid, which was practically by permanganate. When the idea was first started, this material was very expensive, but now it was comparatively cheap, and the effect was that the effluent, by a moderate addition of permanganate, could be entirely deodorised so that it would come out of the works a practically clear inodorous liquid. He thought the ratepayers ought to be very grateful to the Board of Works for adopting so economical a scheme, and for a good many years to come there would be no nuisance produced. The question of the water supply he would not attempt to deal with, but he did not think London would ever be supplied with water pumped up from wells in London. No nuisance would certainly re-appear until the population reached eight or ten millions. It should also be borne in mind that not one penny which this proposed scheme proposed would be lost, although some other scheme might be adopted—everything to be used would be available if ever a better process was brought forward. Meantime, the metropolis would save from £150,000 to £200,000 over any other proposed plan. One word more with regard to the pressed cake. There was no doubt that this process of pressing cakes had been a god-send for the precipitating process, because sludge was always very difficult to deal with, and when pressed it was comparatively easily disposed of, though not so easily as some people imagined. It was a well-known trick of counsel, in sewage cases, to have a large cake of this pressed sludge brought into Court to point out how inodorous it was, and to almost advise persons to take it home and place it on the mantelpiece; but it was not said that that was generally especially pressed cake very carefully dried by exposure to the air. If you took that cake and bottled it up and moistened it, and then smelt it again a week after, no one would think of recommending it to be kept in a dining-room. They had all heard Dr. Tidy's story about walking about amongst thousands of tons of this, which really smelt rather nice; but he had had the misfortune also to go about this heap of thousands of tons, having visited it on a cold May morning, when there had been a frost during the night—a very unfavourable time for producing smells. He visited the heap with the engineer, who told them that he could not smell anything, but after going some distance in the direction of the wind, they found it really very offensive. The engineer said he never smelt it so strong before, although it was a cold morning; they went as far as they could, and measured the distance, and found it was 600 yards, and there the smell was most powerful and offensive. He would therefore warn anyone who had to dispose of this compressed cake, not to simply think it could be thrown up in heaps and left to itself, or that it could be used to raise ground or to build upon. The only way to deal with it was either to dig it into the ground where it could be disposed of as manure, or if it were to be used for raising ground, it must be done by mixing it with the proper proportion of earth. What the proportion was he would not undertake to say, but it must be the proper proportion. In conclusion, he would say that this question of dealing with sewage was of such enormous magnitude that it ought not to be made a battle ground between opposing interests and rivalries of any kind. It could only be dealt with for the benefit of the country, if every one who had any knowledge on the question did his best to advance regardless of what other people might think. Let everybody fairly co-operate in the question, and above all let every one give to those who might be opposed to him credit for being actuated by the same honourable motives as he was himself.

Professor DEWAR, F.R.S., said he could not see, after what they had heard from Dr. Dupré, that precipitation was not now generally admitted, at any rate as a preliminary, for he admitted that precipitation in some form was required. He totally differed from the views of Lieutenant-Colonel Jones, who said that if the solid material could be separated, the effluent or supernatant liquid would be quite as good as if any kind of chemicals had been added. He had, in conjunction with Mr. Stevenson, in dealing with the sewage of Dunse, there adopted mechanical means for the separation of the solids in suspension; ultimately they were forced into using not only the ingenious mechanical methods Mr. Stevenson had devised, but also sulphate of alumina. This was simply because, although the ultimate treatment was satisfactorily irrigated, land invariably failed in patches. The owner objected to the area of land, because, he said, it was not in the first instance enough, and in the next place it was becoming continually inefficient. They were to be congratulated if Dr. Tidy's paper had led to agreement on this one point, that chemical precipitation was an advantage in any case. There could be no doubt whatever, as Dr. Percy Frankland had stated, as Dr. Dupré had admitted, and as no doubt Dr. Frankland held, that the present views as to the natural purification of water by soil were far from being clear. The fact was that the nitrification ferment itself had not yet been worked out. A few nights ago Dr. Klein was asked if, after all the work which had been done in that particular department, he was not convinced it was a bacterium, and he said, No. At the present time undoubtedly if they could cultivate these organisms, it would be a good thing for agriculture in the future. He had sometimes speculated as to what possibly might be the explanation of what appeared to be the delusion of the public in paying for some manurial agents which otherwise did not seem to have such a high value, and after considering the evidence submitted in print, which was certainly left uncontradicted, as to the veracity of the parties, he could only come to the conclusion that this particular substance, separated from sewage, seemed to be eminently valuable as a pabulum for the growth of this nitrification agent, so that he did not at all despair of its being shown in the future that the sewage material, although it would appear at first to be insufficient as compared with nitrate of ammonia or phosphates, might have other advantages which were not yet known, especially with regard to the possible decomposition of nitrogenous matter in the soil, which was now attracting the attention of some of the ablest chemists. He must, however, put Dr. Dupré right on one point, for he did not like to have any apparent disputes with him with reference to the Aylesbury experiments. He had examined the figures, but the comparison he made was merely with the volatile matter after the addition of all the materials—clay and other materials—with what the sewage was originally; but that had nothing to do with the fact that three-fourths of the readily oxidisable organic matter was removed. He took it that Dr. Dupré would admit now that the effluent ought to be oxidised, in order to make it anything like fit to be placed in a river. It was exceedingly surprising that there should be no limit to the amount of chemicals which could be used. It would seem that neither was there any particular limit which was best on the average, or any one particular substance which was better than another. He could not help thinking that the combination Dr. Dupré had selected, in conjunction with other distinguished men, required a little explanation from a chemical point of view. He took it that the addition of lime and sulphate of iron gave rise to protoxide of iron, which withdrew a considerable amount of oxygen from the water. Subsequently, he understood that permanganate was to be added. He had not the slightest hesitation in stating that the samples of effluent he had seen resulting from this process were the worst from any precipitation process whatever. He had only seen two samples, and they might be special occasions. If an oxidising agent be added to the raw sewage, a much larger amount of material would be used than was necessarily required; but he held that, whether you used charcoal or clay, he was not quite sure that there was not a great deal more in the use of proper clay than had yet been worked out. What was required for the purpose of separating the particular bodies in sewage was some kind of colloidal body, that employed was simply oxide of alumina; but clay itself in certain forms finely divided was well known to be an exceedingly colloidal substance, and acted not so much by its weight as by those very properties which oxide of alumina possessed. Consequently, if you added all this material to the sewage, one fact was certain—he did not understand how the blood had anything to do with it—that 5-6ths of the readily oxidised organic matter at any rate could be taken out. Therefore, there was 5-6ths less, and what he thought should be demanded was this, that if any precipitation treatment was adopted at all, it should be a thorough one. Even if it were a failure, it would be well worth the money it would cost. If 5-6ths of the organic matter were withdrawn by precipitation, he should like to know what dilution the 1-6th left in solution would stand in many water courses. Any precipitation experiment ought not to be confined to the exigencies of the locality. That might do as a defence, but when dealing with it in the large interests of London, it ought to be thorough and efficient. He could not help thinking that the mere minimum test was hardly a fair one under the circumstances. It would be much better to spend double the money in the primary experiments than to add on the other half to the refinement of a secondary precipitation involving oxidation.

Mr. DIBDIN said it would be difficult to speak on this subject without going over a good deal of the ground which Dr. Dupré had already traversed, but he might refer to one point mentioned by Professor Dewar, the action of an iron salt in combination with the action of the permanganate. He thought there was a little confusion in Professor Dewar's mind with regard to this question of oxidation, and it was a mistake quite as common as the idea that because a glass of effluent water was clear, therefore it was pure. The very large experiments he had made on sewage precipitation proved that there was no greater fallacy before the public than that a glass of clear effluent water was necessarily pure, and had the greater part of the dissolved impurities removed from it, and so on, as the public were frequently told by inventors when they talked about the benefits which would accrue to humanity if their particular patents were adopted. He had got somewhat casehardened in this matter, having examined all the processes before the public, and was now thoroughly convinced that no process of precipitation, whatever quantity of chemicals were used, or whatever chemicals practically available were used, materially affected the dissolved matters. He had tried it in the quantity proposed by Dr. Tidy, and had increased that quantity to 10, 20, 50, and even 100 times, using as much as 700 grains of lime, 500 grains of sulphate of alumina and 100 grains of sulphate of iron per gallon, and found that the effluent was really worse than when they used the minimum quantity. This large quantity of lime, in fact, dissolved some of the suspended matters and put them into solution, and although it produced a brilliantly clear effluent, without the slightest particle of suspended matter, yet it was worse than the original sewage when merely strained through filter paper. This observation had been confirmed not only by the eminent chemists who had worked with him, but by others also. Not many days since he had in his hand a report in which an effluent was reported on by Dr. Bell, of Somerset-house, to obtain which a large quantity of lime had been used, about 70 grains per gallon, and after careful examination more organic matter was found in the effluent than there was in the sewage. To come back to the question of the oxygen, Professor Dewar said he could not understand, if iron were added to the sewage in the presence of lime, as there was protoxide of iron precipitated, which withdrew oxygen from the sewage, and then permanganate was added to replace that oxygen, what advantage there was in the process. But there was a difference, as most chemists knew, between nascent oxygen, or active oxygen, and atmospheric oxygen, or that which was merely dissolved in the water. Now the protoxide of iron would absorb the oxygen dissolved in the water, which was practically, if not wholly, inert in oxidising the organic matter in the water, whereas when the protoxide of iron was converted into sesquioxide, it parted with that excess of oxygen taken from the water, and gave it up again to the sewage; thus there was a direct immediate oxidation brought about. In the one case, where there was plenty of oxygen from the atmosphere, which might be dissolved in the water by the agency of the iron, that was carried to the sewage, whereas sewage by itself would not take it; and in the other case you had the oxygen of the permanganate acting directly on the organic matter in the effluent. The action of the iron was merely that of a carrier of oxygen, whilst the permanganic acid was a direct oxidiser. The other points had been very ably dealt with by Dr. Dupré; but he would especially call attention again to the fact that, whether this process of precipitation was the best or not, it was one which there was good reason for believing was suitable for the purpose in view, and would effect an enormous difference in the character of London sewage, so much so that it was probable that it would be twenty or thirty years before any change was required, even if it were then, supposing there were no improvement in chemical processes. But should it happen that another chemical process of far better character should be discovered, not one farthing of the money spent would be lost, because the tanks and apparatus would be equally available for the improved process as for the one proposed. They believed they were on the right track, and were doing what was right in the interests of sanitation and the ratepayers.

Mr. Willis Bund said there was one point in the paper which had not yet been adverted to in the discussion, and that was the reference to the Rivers Pollution Bill, and the standards of what should be discharged into the river and what should not. He was, to a great extent, responsible for that Bill; and as it was intended in another year to endeavour to pass a Bill on the same basis, he should like to know whether the meeting agreed or disagreed with the very strong condemnation which Dr. Tidy had passed upon the measure. He said the measure was wrong in theory, and there he joined issue with him at once. It was right in principle, though it might be wrong in some details. The principle was, that it was desirable to have some cheap and simple remedy, and therefore powers were given to any person aggrieved to complain to the County-court and get a summary remedy. Then Dr. Tidy said they must leave the manufacturers alone altogether. He wished they could; but he forgot that in the Act of 1876 a clause was inserted which gave manufacturers a right to turn their refuse into sewers, and the consequence was that at the present day they had to deal in many cases not merely with sewage, but with the refuse of manufactories as well. That being so, a great many tests were proposed which might do very well in the case of pure sewage, but wholly failed to meet the case which had to be met in many towns in this country. Dr. Tidy had put forward four practical tests—as he called them. He would not speak of them from a chemical point of view, but he did venture to say that they would be utterly useless from the point of view for which they were required—namely, to see whether the test could be worked or not. The first was, that the effluent should be clear and colourless when seen in a white cylindrical bottle. Now, if there were any colour at all in what he had in the bottle, of course the person complained of would say it was not sewage, it was the refuse of Mr. A. or Mr. B.'s manufactory, and you would at once be driven back to prove (if it were capable of proof) that the colour arose from sewage. Then the next test was that it should not be alkaline to test paper. So the same difficulty would occur, did the alkalinity arise from sewage or from the refuse of a manufactory? A third test was that the addition of one grain of sulphate of alumina should not produce appreciable turbidity. What was appreciable turbidity? There you at once got the whole question at large again. The fourth test was that when shaken up in a bottle and left for ten minutes, it should not leave foam, or much froth. In attempting to enforce any law based on such standards, inevitable difficulties would arise. The question of whether they should be standards at all was worthy of discussion; last, he protested strongly against a gentleman of the high authority of Dr. Tidy putting forward what he called common-sense standards, when, if they were put into any Act of Parliament, they would render it even worse than it was at present.

Dr. Edmunds asked if it were not possible to adjourn the discussion.

The Chairman said that he could not promise that the discussion should be resumed this session, but the Council would endeavour to fix another evening, due notice of which would be given in the *Journal.*

Mr. Bailey-Denton sends the following particulars respecting his scheme in relation to metropolitan sewage and Thames purification, in which he gives a comparison of the outlay involved by the intended chemical treatment at the existing outfalls by the Metropolitan Board with that attending the Canvey Island scheme:—

At the Outfalls, Barking and Crossness.

Assumed prospective population, 5,200,000, with outflow of 30 gallons a head (*sic*) = 156,500,000 gallons daily. Rateable value (1886), metropolitan district only, £30,598,317. A penny rate raises £127,493.

Estimated outlay (Lea Valley excluded). On the designs of the Engineer and Chemist of the Board. "First" expenditure of capital in permanent works.

No. 1 Scheme.

To effect the *complete* separation of the solid portion from the liquid—the latter passing into the river clarified, but still not sufficiently free from noxious matters as to be permanently discharged into it:—£1,130,000.

Working and Currents.

	£
Interest, 3 per cent. on capital outlay, £1,130,000	33,900
Chemicals	83,000
Pressing of sludge into cakes (1,000 tons per diem)	73,000
Disposal of pressed sludge, freight or loss	36,500
Labour and pumping	26,500
	252,900
Contingencies, 10 per cent. on £219,000	21,900
	274,800
Add for deodorisation for 12 months, instead of 3 months only as proposed	21,000
	£295,800

A charge of $2\frac{1}{3}$d. in the £ will be required to raise this amount.

No. 2 Scheme.

To effect partial separation only, the quantity precipitated being two-thirds of No. 1, the remaining one-third passing into the river with the liquid which itself would not be sufficiently free from noxious matters as to be admissible without further purification:—£1,140,000 (including £131,000 for barges).

Working and Current Expenses.

	£
Interest, 3 per cent. on capital outlay, £1,140,000	34,200
Chemicals	22,000
Barging to sea (utterly inadequate)	37,200
Wear and tear and cost of maintenance of barges, 10 per cent. on £131,000	13,100
Labour and pumping	26,300
	132,800
Contingencies, 10 per cent. on £98,600	9,860
	£142,660
Add for deodorisation for 12 months, instead of 3 months as proposed	21,000
	£163,660

A charge of $1\frac{1}{4}$d. in the £ will not quite reach this amount.

At Canvey Island, 21 Miles Below Barking.

Assumed prospective population, including the lower portion of the Lea Valley, 6,000,000. Outflow: Metropolis 200,000,000, Lea Valley 20,000,000 = 220,000,000 gallons daily. Rateable value, including all places on the Lea below Waltham, £32,162,864. A penny rate raises £134,012.

Estimated Aggregate Outlay (including provision for the Lea Valley).

	£
1. Cost of conduit, designed and estimated for by Sir Joseph Bazalgette, to extend the metropolitan outfalls, when united, to Thames Haven, with terminal, storage, and tidal reservoirs, and outlet appliances which will not be required if the sewage be treated on Canvey Island. (Discharging capacity, 358,848,000 gallons per diem).	*3,366,000
2. Further extension of the same conduit into Canvey Island, with distributing conduits and appliances, and the immediate formation of earthen basins to receive the solid portion, and intermittent filtration beds to cleanse the liquid after its separation from the solid for $53\frac{1}{3}$ years, the first instalment of a provision for 100 years and more	†1,040,000
3. Price of Canvey Island, 4,383 acres (freehold), including compensation to occupiers and costs of purchase, as well as the expense of removing the village, the church, the schools, the vicarage, &c., &c.	‡267,017
	£4,673,017

Working and Current Expenses.

		£
Interest 3 per cent. on capital outlay £4,673,017 =		140,190
Pumping—Sir Joseph Bazalgette's estimate	£37,400	
Add for extra lift, if necessary	3,740	
		41,140
Labour (the work being for the most part automatic)		7,800
Chemicals, if found necessary, to quicken the mechanical deposition of the solids		15,000
		204,130
Contingencies 10 per cent. on £63,950 =		6,395
		210,525
Deduct for the relinquishment of the terminal reservoirs and appliances at Thames Haven, and the avoidance of the labour incidental thereto—not required		15,000
		£195,525

A charge of $1\frac{1}{2}$d. in the £ will more than suffice to raise this amount, and the income from the property in the island will cover the local charges and maintenance of sea wall.

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* These figures are those of the Metropolitan Board.

† These figures are based upon plans, sections, and estimates prepared for presentation.

‡ These figures are based upon existing optional contracts to purchase to the extent of seven-ninths of the whole island, advantageously made during depression in value.

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COLONIAL AND INDIAN EXHIBITION.

OPENING CEREMONY.

The Colonial and Indian Exhibition, which was first contemplated in 1878, and the actual preparation for which was commenced in 1874, was opened by her Majesty the Queen on Tuesday, May 4th, with all the pomp and ceremony befitting the occasion.

The holders of season tickets, and the public on payment of one sovereign each, were admitted to the Exhibition between the hours of 9.30 and 11 o'clock at the India Museum, the School of Art Needlework (Exhibition-road), the Queen's-gate upper entrance, and the Queen's-gate lower entrance. All doors were closed punctually at 11 o'clock, and no money was taken and no person admitted after that time. Separate admission was obtainable to the Royal Albert-hall, on presentation of special tickets, by all entrances of the hall, except the royal entrance and the entrance from the Conservatory. The doors of the hall were opened at 10.30 and closed punctually at 11.30. The main entrance to the Exhibition, in the Exhibition-road, was available only for those taking part in the procession. Various seats were placed at the disposal of visitors along the line of route. Such chairs were unnumbered, but the front row was in all cases reserved for ladies. Her Majesty's Commissioners for the Colonial and Indian Exhibition, and others taking part in the procession, assembled in the Colonial Hall, main entrance, Exhibition-road, at 11.15 a.m.

At 11.30 o'clock, his Royal Highness the Prince of Wales, K.G. (the Executive President of the Royal Commission), accompanied by their Royal Highnesses the Princess of Wales, the Princesses Louise, Victoria, and Maud, and the Prince Albert Victor of Wales, K.G., arrived at the Exhibition, accompanied by an escort of the 2nd Life Guards.

The Queen left Windsor Castle at 11.10 and travelled by the Great Western Railway to Paddington Station, where the Royal carriages were in waiting at the arrival platform. The route was by London-street, Oxford and Cambridge-terraces, Bayswater-road, Alexandra-gate, Serpentine-bridge, and Prince's-gate, to Exhibition-road. On the arrival of her Majesty at the main entrance in the Exhibition-road, which was announced by a flourish of trumpets by her Majesty's state trumpeters, her Majesty was received by his Royal Highness the Executive President and the other members of the Royal Family. The Chief Executive Commissioners for the various Colonies and India were presented to her Majesty by his Royal Highness the Executive President at the base of the statue of his Royal Highness in the Colonial Hall. After their presentation, the Executive Commissioners, whether Royal Commissioners or otherwise, joined the procession in their several places. A procession was then formed in the following order:—

Pursuivants of Arms:
Portcullis. Bluemantle.
Rouge Croix. Rouge Dragon.
The Assistant Secretaries and the Official Agent to the Royal Commission.
Members of the Finance and Lighting Committees.
Heralds:
Surrey (*Extraordinary*).
Richmond. Lancaster.
Somerset. Windsor.
York. Chester.
Her Majesty's Commissioners.
The Executive Commissioners for the Colonies and India.
Norroy King of Arms. Clarenceux King of Arms.
Senior Gentleman Usher in Waiting. Comptroller in the Lord Chamberlain's Department.
Comptroller of the Household. Vice-Chamberlain. Treasurer of the Household.
Gentleman Usher in Waiting. Garter King of Arms. Gentleman Usher in Waiting.
Lord Chamberlain. Lord Steward.
His Royal Highness the Duke of Connaught and Strathearne, K G. The QUEEN. His Royal Highness the Prince of Wales, K.G.
Her Royal Highness the Hereditary Grand Duchess of Oldenburg. Her Royal Highness the Princess of Wales. Her Imperial and Royal Highness the Crown Princess of Germany and of Prussia.
Their Royal Highnesses
The Princess Beatrice, Princess Henry of Battenberg. The Princess Christian of Schleswig-Holstein. The Princess Louise, Marchioness of Lorne.

Her Royal Highness the Duchess of Teck.
Her Royal and Imperial Highness the Duchess of Edinburgh, with his Royal Highness the Prince Alfred of Edinburgh.
Her Royal Highness the Duchess of Connaught and Strathearne.

Their Royal Highnesses
The Princess Victoria of Wales.
The Princess Louise of Wales.

Her Serene Highness the Princess Victoria of Teck.
Her Royal Highness the Princess Maud of Wales.
Her Grand Ducal Highness the Princess Louis of Battenburg.

Their Royal Highnesses
The Hereditary Grand Duke of Oldenburg.
The Duke of Cambridge, K.G.
The Prince Albert Victor of Wales, K.G.
The Prince Christian of Schleswig-Holstein, K.G.

The Marquis of Lorne, K.T.
His Serene Highness the Duke of Teck, G.C.B.,
His Royal Highness the Prince Henry of Battenberg, K.G.
His Serene Highness the Prince Louis of Battenberg, K.C.B.

The Chief Commissioner of Police.
The Secretary to the Royal Commission.
Acting Mistress of the Robes.
Lady of the Bedchamber.
Maids of Honour.
Woman of the Bedchamber.
Ladies in Attendance on the Royal Family.
Gold Stick in Waiting.
Master of the Horse.
Captain of the Yeomen of the Guard.
Captain of the Gentlemen at Arms.
Groom in Waiting.
Lord in Waiting.
Keeper of her Majesty's Privy Purse.
Equerries in Waiting.
Silver Stick in Waiting.
Field Officer in Brigade Waiting.
Gentlemen in Waiting on the Royal Family.

All persons in the procession wore levee, academical, or Court dress or uniform. Ladies were in morning dress. The procession, starting from the Colonial Hall (principal entrance), proceeded through the Indian Hall (inner vestibule), along India (middle court of the south gallery), and between the Indian Bazaar and Ceylon (north court of the south galleries); then, between the Indian Palace and the entrance to the "Old London" street, between the Australasian Colonies (central avenue), into Canada (central gallery); and, turning to the right, passed across the North Annexe, through the gardens to the right of the fountain basin, and through the conservatory, and entered the Royal Albert Hall by a special entrance constructed for the occasion. The Chair of State was placed on the daïs in the Albert Hall. Above it was a canopy of Indian cloth of gold, surmounted by a baldachino of rich gold-embroidered velvet, looped with chains and pendants of gold and silver Delhi work, and slightly closed in at the sides with curtains of red embroidered velvet. The throne itself, of hammered gold, was formerly in the possession of the East India Company; and immediately above it, on the back of the canopy, embroidered in gold letters and surmounted by the Imperial Crown, was the monogram of Victoria, Queen and Empress.

Upon the procession entering the Albert Hall, her Majesty's Commissioners, the Executive Commissioners, and the Members of the Committees took their seats reserved for them in the arena of the hall. The Queen took her place in front of the Chair of State, with his Royal Highness the Prince of Wales at her Majesty's right hand, and his Royal Highness the Duke of Connaught on her left, the other members of the Royal Family standing on either side, with the great officers of state and the ladies and gentlemen of the household around them. The Archbishop of Canterbury and the Bishop of London, who had previously arrived, stood on the left of the dais, and the Secretary of State for the Home Department near her Majesty, on the right. The Heralds stood in front of the dais.

Upon the procession entering the Albert Hall, the first verse of the National Anthem was sung in English by the Royal Albert Hall Choral Society, under the direction of Mr. Barnby. As her Majesty reached the dais, the second verse of the National Anthem was sung in Sanskrit, translated by Professor Max Müller; and the third verse was sung in English. The following ode—written for the occasion, at the special desire of the Prince of Wales, by the Poet Laureate, Lord Tennyson, and specially set to music, at the request of his Royal Highness, by Sir Arthur Sullivan—was then sung by Madame Albani and the choir, under the direction of the composer:—

I.

Welcome, welcome with one voice!
In your welfare we rejoice,
Sons and brothers, that have sent,
From isle and cape and continent,
Produce of your field and flood,
Mount and mine, and primal wood,
Works of subtle brain and hand,
And splendours of the Morning Land,
Gifts from every British zone!
Britons, hold your own!

II.

May we find, as ages run,
The mother featured in the son,
And may yours for ever be
That old strength and constancy,
Which has made your Fathers great,
In our ancient island-state!
And,—where'er her flag may fly
Glorying between sea and sky—
Makes the might of Britain known!
Britons, hold your own!

III.

Britain fought her sons of yore,
Britain fail'd; and never more,
Careless of her growing kin,
Shall we sin our fathers' sin,
Men that in a narrower day—
Unprophetic rulers they—
Drove from out the Mother's nest
That young eagle of the West,
To forage for herself alone!
Britons, hold your own!

IV.

Sharers of our glorious past,
Brothers, must we part at last?
Shall not we thro' good and ill
Cleave to one another still?

Britain's myriad voices call
" Sons, be welded, each and all,
Into one Imperial whole,
One with Britain heart and soul!
One life, one flag, one fleet, one Throne!"
Britons, hold your own!
And God guard all!

His Royal Highness the Prince of Wales then read the following address to her Majesty, and presented to her Majesty a catalogue of the articles exhibited, the general handbook, and the key of the Exhibition :—

"MAY IT PLEASE YOUR MAJESTY,—As Executive President of the Royal Commissioners appointed by your Majesty's royal warrant of the 8th of November, 1884, for the promotion of an exhibition of the British Colonial and Indian Empire, and subsequently incorporated by your Majesty's Royal Charter of the 15th September, 1885, I humbly beg leave to lay before you a brief statement of our proceedings up to the present time. The general interest manifested in the display made by your Majesty's Colonial and Indian Empire at the Paris Exhibition of 1878, led me, as President of the British Commission, to express a hope that an opportunity might soon occur by which your Majesty's subjects in England would be enabled to witness the marvellous development which, under your beneficent rule, their brethren and fellow subjects had attained throughout so many portions of the globe. It was, therefore, with the highest gratification that I accepted your Majesty's gracious invitation to assume the Executive Presidency of this Commission, the appointment of which by your Majesty has been the means of making this hope a reality. The invitations which we were empowered by your Majesty to issue to the Colonial Governments and to the Government of India were forwarded towards the close of the year 1884, and from the answers received it at once became apparent that this undertaking had obtained warm and hearty sympathy throughout your Majesty's dominions. In your Majesty's dominion of Canada, throughout your Australasian, African, West Indian and Eastern Colonies, in your Mediterranean possessions and elsewhere, grants were voted, Commissions formed, and Executive Commissioners appointed. That the work of preparation was undertaken with enthusiasm and attended with success, is evident from the complete and varied collections which at present fill the buildings through which your Majesty has just passed. The response received from the Government of India was also of the most cordial character. His Excellency the Viceroy caused, through the Revenue and Agricultural Department, instructions to be issued to every district of your Majesty's Indian Empire for the collection of objects illustrative of the arts, manufactures, and resources of that great realm. These collections, which now adorn a large section of the Exhibition, have been supplemented by generous contributions from their Highnesses the Princes of India, by collections the formation of which we ourselves have authorised, and by the contributions of private native exhibitors. We are desirous of bringing under your Majesty's notice our deep appreciation of the hearty co-operation of the Colonial Governments in this Exhibition, and of taking this exceptional opportunity of stating how greatly we are indebted to the Commissions appointed by these Governments, and to the Executive Commissioners on whom the superintendence of the entire work of installation has devolved. We further desire to record the valuable assistance which we have received from your Majesty's Viceroy, from the Supreme Government of India, and from the various officials who have so ably and thoroughly carried out their instructions. Our grateful thanks are also due to the Colonial Governments, to the Government of India, to the Corporation of the City of London, to many City Companies, and to the firms and individuals who have contributed to the guarantee fund. The fact that the list of subscribers not only includes those whose interests are likely to be specially affected by the Exhibition, but also comprehends every class of the community, supplies a gratifying proof of the universal sympathy and interest which this undertaking has aroused. We venture to avail ourselves of this opportunity to convey to your Majesty our dutiful and loyal acknowledgements of the interest which your Majesty has been pleased to take in our labours, proved as it is by your Majesty's presence here to-day; nor can I resist a reference to a similar ceremonial, presided over by your Majesty but a few paces from this spot thirty-five years ago. On that memorable occasion, the first of its kind, the Prince Consort, my beloved and revered father, filled the position which I, following in his footsteps at however great a distance, now have the honour and gratification of occupying. Your Majesty alone can fully realise with what deep interest my beloved father would, had he been spared, have watched, as their originator, the development of exhibitions both in this country and abroad; and with what especial pleasure he would have welcomed one having for its object the prosperiy of your Majesty's Empire, the interests of which he had so much at heart. In the Great Exhibition of 1851, your Majesty's Colonial and Indian Possessions indeed were represented, but their importance was then but little realised, and their present greatness was at that time unforeseen. During the years that have elapsed since 1851, few greater changes have been wrought than the marvellous development of the outlying portions of your Majesty's Empire. It is our heartfelt prayer that an undertaking intended to illustrate and to record this development may give a stimulus to the commercial interests and intercourse of all parts of your Majesty's dominions; that it may be the means of augmenting that warm affection and brotherly sympathy which is reciprocated by your Majesty's subjects, and that it may still further deepen that steadfast loyalty which we, who dwell in the Mother Country, share with our kindred who have elsewhere so nobly done honour to her name."

Her Majesty the Queen read the following reply, handed to her by her Majesty's Secretary of State for the Home Department:—"I receive with the greatest satisfaction the address which you have presented to me on the opening of this Exhibition. I have observed with a warm and increasing interest the progress of your proceedings in the execution of the duties entrusted to you by the Royal Commission, and it affords me sincere gratification to witness the successful result of your judicious and unremitting exertions, in the magnificent Exhibition which has been gathered together here to-day. I am deeply moved by your reference to the circumstances in which the ceremony of 1851 took place, and I heartily concur in the belief you have expressed that the Prince Consort, my beloved husband, had he been spared, would have witnessed with intense interest the development of his ideas, and would, I may add, have seen with pleasure our son taking the lead in the movement of which he was the originator. I cordially concur with you in the prayer that this undertaking may be the means of imparting a stimulus to the commercial interests and intercourse of all parts of my dominions, by encouraging the arts of peace and industry, and by strengthening the bonds of union which now exists in every portion of my Empire."

Her Majesty then commanded the Lord Chamberlain to declare "The Exhibition open." The declaration, having been made, was announced to the public by a flourish of trumpets by her Majesty's state trumpeters stationed in the Hall, and by the firing of a royal salute in Hyde-park. The following prayer was then offered by his Grace the Archbishop of Canterbury:—

"Almighty God and Heavenly Father, we beseech Thee to send down Thy gracious blessing upon the manifold treasures and precious works which from amongst our kindred peoples and our fellow nations, from sunrise round to sunrise, are gathered here for glory and for beauty, unto the increase of knowledge, use, and wisdom. Bless our Sovereign Lady the Queen, and enrich her days with abundance of peace, that all the daughter-lands of her Realms and Empire may be knit together in perfect unity and prosperous strength. And grant that, as her people inherit and fill peacefully all countries of her dominion, so not material concernments only but the enduring riches of mind and spirit, and the righteousnes of Thine eternal Kingdom, may be sacred and dear to them; so that, in Thy bounteous gifts, and in man's wise labours learnt of Thee, Thy Name may evermore be greatly magnified; through Jesus Christ our Lord. Amen."

The prayer was followed by the "Hallelujah Chorus," sung by the choir under the direction of Mr. Barnby. Madame Albani then sang "Home, Sweet Home." "Rule Britannia" was sung by the choir, as her Majesty left the building.

Dr. Stainer played the organ.

Her Majesty left the Exhibition by the Royal entrance of the Albert Hall, accompanied by the Royal Family and attended by the Household in Waiting. On leaving the Hall, the Queen proceeded to Buckingham Palace by Knightsbridge-road, Prince's-gate, Hyde-park, and Constitution-hill.

The route of the procession from the railway station at Paddington to the Exhibition, and from thence to Buckingham-palace, was kept by Life Guards.

Guards of honour of the Coldstream Guards and of the Grenadier Guards mounted at the main entrance in Exhibition-road, and at the Royal entrance at the Albert Hall, respectively. A battery of Royal Horse Artillery was stationed in Hyde-park to fire the Royal Salute. The Honourable Corps of Gentlemen at Arms was on duty at the Albert Hall, and the Yeomen of the Guard in the Exhibition buildings. Her Majesty's State trumpeters were on duty. The bands of the Grenadier Guards, the Coldstream Guards, and the Second Life Guards, placed throughout the buildings, played during the morning.

The number of visitors to the Exhibition on the opening day was 37,241, of which 17,241 entered after the doors had been thrown open at 4 p.m. for the ordinary shilling admission.

MEETING OF THE ROYAL COMMISSION.

The Royal Commission, which had not met formally since the first meeting held at Marlborough House on the 30th March, 1885, assembled on Monday, May 3, in the Durbar Hall of the Indian Palace at the Exhibition, to receive the Executive President, His Royal Highness the Prince of Wales, K.G.

THE PRINCE OF WALES addressed the meeting as follows:—

MY LORDS AND GENTLEMEN,—I have thought it right to call you together on this the eve of the opening of the Exhibition by her Majesty the Queen, in order that I may report to you the various steps that have been taken in the preparations for this Exhibition since the last time I had the honour of addressing you. I would, in the first place, wish to say a few words with regard to the constitution of the Royal Commission. You are, doubtless, aware that her Majesty, in requesting you to act on a Royal Commission, defined your duties to be for the purpose of advising upon the best mode by which the products of industry, agriculture, and the fine arts of her Majesty's Colonial and Indian dominions might be procured and sent to this Exhibition. The appointment of this Commission was, I understand, framed upon the precedent of the Exhibition of 1851, and following the example of that Exhibition, it was thought desirable that a charter should be applied for which should make the Royal Commission a body corporate, and which should give it power to organise and carry on such an Exhibition. This charter was granted on the 15th September, 1885. You will, perhaps, remember that, in my last address, I informed you of the initiative action which I, as your Executive President, had taken, and which you were kind enough then to confirm in order that the proposals for holding a Colonial and Indian Exhibition should be properly brought to the notice of the Governments of India and of the various Colonies. I then stated that from the answers which had been received from the Colonies and from India it was clear that this Exhibition would receive the hearty co-operation of all concerned. I need only ask you to make an inspection of the various sections of the Exhibition to-day, before leaving the buildings, for you to at once realise how cordially the Governments of India and of the various Colonies have acceded to the invitation which I, as your President, forwarded to them in November, 1884; and I am sure that you will join with me in requesting the Executive Commissioners to take an early opportunity of conveying to their Governments the sincere thanks of the Royal Commission for having so thoroughly realised our views as to the form that this Exhibition should take. To these gentlemen themselves are also due our own warmest acknowledgments. I feel also convinced that you will consider it a pleasing duty to record the deep obligation we are under to His Excellency the Viceroy and the Supreme Government of India for the admirable organisation which, under the direction of Mr. Buck, has been displayed by the Revenue and Agricultural Department, and by the officers who have assisted it. I further propose that we should request the Viceroy to express our acknowledgments to their Highnesses the Princes of India, who have, by their liberal contributions, so materially added to the beauty and interest of the Indian Section. With regard to the administration of the Royal Commission, I may state that the Finance Committee—the appointment of which you confirmed at the last meeting—is most carefully discharging the duties which you then confided to it. I have to ask you to confirm the appointment of the following gentlemen, who were good enough to accept my invitation to be added to it—The Right Hon. Sir Lyon Playfair, the Hon. Sir Ashley Eden, Right Hon. Sir Henry Thurstan Holland, Mr. E. W. Hamilton, Mr. A W. Gadesden. It is with much pleasure that I am able to report that the Guarantee Fund, which at the time of the last meeting amounted to £128,600, has now reached a total of £218,430. Of this amount the Corporation of the City of London has voted £10,000, and among the contributors are many of the great City Companies. I am sure you will agree with me in cordially thanking these corporations, and the gentlemen to whose liberality this very satisfactory result is due. They may rest assured that no endeavour will be spared to prevent the necessity of having recourse to the contributions which they have so generously placed at our disposal. I have to ask you to confirm the appointment of a committee which I have requested to act for the purpose of superintending the lighting by electricity of the buildings and grounds of the Exhibition. The gentlemen composing the committee are:—Sir Frederick Abel, Chairman; Colonel Sir Francis Bolton, and Mr. W. H. Preece. In order that practical effect may be given to the suggestion which I referred to in my last address—that a hospitable reception should be offered to visitors from the Colonies and India, and that facilities should be given to them for visiting the great manufacturing centres and places of interest in Great Britain—I have requested the following members of the Royal Commission to act as a Reception Committee:—The Duke of Abercorn, Chairman; the Earl Cadogan, Vice-Chairman; the Marquis of Lorne, Vice-Chairman. *Colonial Sub-Committee:* The Duke of Manchester, Chairman; the Lord Mayor, Sir Daniel Cooper, Sir Charles Tupper, Sir Thomas Brassey, General Sir Selby Smyth, Sir Charles Hutton Gregory, Sir John Coode, Mr. Arthur Hodgson, Mr. Samuel Morley. *Indian Sub-Committee:* Field-Marshal Lord Napier of Magdala, Chairman; the Right Hon. Sir James Fergusson, Major-General Sir Peter Lumsden, Major-General Sir Henry Rawlinson, Major-General Sir Richard Pollock, Lieutenant-General Sir Charles Brownlow, Lieutenant-General Sir Henry Daly, Lieutenant-General Sir Samuel Browne, Lieutenant-General Sir Harry Lumsden, Sir Barrow Helbert Ellis, Colonel Sir Owen Tudor Burne, Sir George Birdwood; Mr. Arthur Hodgson, General Secretary; Lieutenant-General Henry K. Burne, Secretary; Mr. H. Trueman Wood, Secretary. I trust that the fund which has been inaugurated by them for the above purpose, may before long reach a handsome amount, and feel assured that no efforts will be spared throughout the country to render the visit of our kinsmen a pleasant one. Acting on the precedent of the organisation of the Great Exhibition of 1851, I some time since caused a letter to be addressed to all the mayors and Local Boards of the United Kingdom, suggesting to them the advisability of bringing before the working classes of their various districts the benefits that would ensue from the formation of clubs by subscribing weekly, to which a sufficient sum of money would be laid by to enable the members to visit the Exhibition. I am happy to state that this suggestion has been responded to in many places, and I trust that a large number of the working classes, who would otherwise have found it impossible to come here, will visit the Exhibition, and will benefit by the vast amount of instruction to be derived therefrom. I am very sensible of the facilities which the railway companies have afforded to me in this matter; without the valuable assistance which they have extended, it would have been impossible to have obtained so much success in the formation of these clubs. I must take this opportunity of requesting you also to join with me in acknowledging the help which the railway companies have promised to the Royal Commission for conveying all classes of visitors to the Exhibition. I have appointed a committee, consisting largely of Executive Commissioners, for organising a series of conferences and lectures during the summer on subjects cognate to the Exhibition, and am happy to state that I have been promised the aid of the Councils of the Society of Arts and the Royal Colonial Institute in this matter. I have gratefully accepted an offer made by the Lords of the Committee on Education to give facilities to visitors to the Exhibition for viewing the India Museum. I have sanctioned arrangements by which the Royal Albert Hall forms an integral part of the Exhibition, and by which the National Fish Culture Association maintains the Aquarium, which has always formed a very popular attraction at previous exhibitions; facilities have also been given to the Royal Horticultural Society for the holding of their flower and fruit shows in the Conservatory of the Exhibition. I am desirous of expressing my thanks to her Majesty's Board of Customs for having so greatly facilitated the transmission of goods to the Exhibition. In conclusion, I feel sure that you will join with me in the expression of a desire to record our deep sense of the gracious act which her Majesty the Queen has consented to perform to-morrow. I trust that I shall have the pleasure of meeting you to-morrow morning at half-past eleven o'clock at the principal entrance, where we shall await the arrival of the Queen.

The DUKE OF CAMBRIDGE—Your Royal Highnesses, my Lords and Gentlemen, I have much pleasure in moving the following resolution:—"That this meeting of the Royal Commission for the Colonial and Indian Exhibition, having heard the address of his Royal Highness the Prince of Wales, Executive President, in which his Royal Highness informs the Royal Commission of the preparations he has caused to be made since the last meeting for the holding of this Exhibition, fully approve of these preparations, and confirm the appointment of the gentlemen referred to by his Royal Highness to act on the Finance, Reception, and Conference Committees. The Royal Commission desire to express their cordial thanks to the Corporation of the City of London, and to the City Companies, firms, and individuals who have since the last meeting contributed to the Guarantee Fund, and in conclusion the Royal Commission wish to record their cordial thanks to his Royal Highness for the able and energetic manner in which he has acted on their behalf as Executive President." I am sure you will adopt this resolution most cordially. After the remarks of his Royal Highness the Prince of Wales, it is unnecessary for me to say much as to the objects of the Exhibition, but there is one point with which the Prince of Wales could not deal with that freedom which I can, and that is the great trouble and pains which his Royal Highness has given to this Exhibition. It is not the first time that his Royal Highness has acted as President in undertakings of this nature, and it is very difficult for any individual to praise him in his presence without appearing fulsome, but it is not fulsome to say that he has always devoted his whole energies to bringing everything to a successful issue with which he is connected. I could see yesterday the results of the extraordinary ability with which those under him have carried out his wishes. This is an Exhibition absolutely confined to her Majesty's Colonial and Indian Dominions, and it stands absolutely alone in that respect; it is admirably adapted to the interests of a great country in that it brings together and shows in one common centre all the advantages which India and the Colonies possess in their respective spheres. I think the way in which these advantages will be brought to notice in this Exhibition will tend to that unanimity and good feeling which happily exist among all branches of her Majesty's subjects, and will consolidate that great Empire to which we are all proud to belong and hope to see extended in a peaceful manner for many generations. I am sure you will cordially and spontaneously vote our thanks to his Royal Highness for the trouble he has taken, and congratulate him on the success he has been able to produce.

EARL GRANVILLE:—The illustrious Duke who has just sat down, has undertaken a task which he has performed most admirably. I have much pleasure in seconding the resolution. After the report we have heard, which shows such an immense deal of comprehensive work done, I think it is right to call attention to the fact that the pivot on which it has all turned has been the exertions of his Royal Highness, and to how exactly in this case he has followed the example of his illustrious father in not being merely an honorary president, but in laying down the general principles and in going into every possible detail likely to ensure the success of the Exhibition. We are desired to thank the various bodies who have assisted, but we must remember that a great deal of their good work has been exacted by the genial influence of his Royal Highness himself. I do not wish to go into many parts of the subject, but one point is connected with my official position at this moment, and that is the beneficial effect which this Exhibition is likely to exert on the Colonial possessions of her Majesty; it will be a great disappointment indeed if it does not contribute to the interchange of commodities between the two countries. I believe the British public is not aware of the enormous resources of the Colonies and the British Empire generally, and it is clear that if so many distinguished Colonial men and women come to this country at this time it will increase not only our knowledge but the personal good feeling which now exists. I heartily concur with the noble Duke in asking you to agree to the resolution he has so well moved.

THE PRINCE OF WALES—Before the meeting disperses, I wish to return you my sincere thanks for the most kind and flattering manner in which my illustrious relative has proposed this vote of thanks, and to the noble Lord who has so ably seconded the same. I can assure you that the compliments you have been kind enough to pay me have been really quite undeserved. I need hardly say that I certainly take the deepest interest in the success of this Exhibition, but really all the arrangements and the trouble that has been taken are owing to Sir Philip Cunliffe-Owen and his two able assistants, Mr. Edward Cunliffe-Owen and Mr. J. R. Royle. I can only say that those who have not yet seen the Exhibition will be satisfied with what they see, if they take the present opportunity of going round the Courts, and they will be struck with the wonderful resources of the Empire. No pains and no expenses have been spared by the Governors and Colonial Commissioners, and by the Executive Commissioners here, to make each of their departments a success, and there has been a peaceful rivalry between them, the one to excel the other. I hope that this Exhibition will be not only entertaining to the eye, and that it will be of material benefit to our own countrymen, but that it will also tend to produce a still greater feeling of brotherly love between ourselves and the rest of her Majesty's subjects. I can only add that I trust that the sun may favour us to-morrow as it has done to-day, and that we may have "Queen's weather" in every sense of the word.

The meeting then terminated.

OFFICIAL INSPECTION.

On Saturday (May 1st) his Royal Highness the Prince of Wales made an official and detailed inspection of the Exhibition. His Royal Highness was received, at the Queen's Gate entrance, by Sir Philip Cunliffe Owen, who conducted him through all the Colonial courts and through the Indian collections. The various Executive Commissioners were presented, in their respective courts, to his Royal Highness, who expressed his great satisfaction at the hearty co-operation of the Colonial Governments and the completeness of the arrangements. His Royal Highness was highly gratified at the magnificent display made by the Indian Empire.

On the evening of Monday (May 3rd) his Royal Highness officially inspected the electric lighting arrangements of the Exhibition.

ROYAL VISIT.

Her Majesty the Queen visited the Exhibition on the morning of Thursday (May 6), and was received by H.R.H. the Prince of Wales, Executive President of the Royal Commission. The Queen was accompanied by their Royal Highnesses the Duke of Connaught and Prince and Princess Henry of Battenberg. Her Majesty visited the Indian Palace, and inspected in detail the work of the native craftsmen, and was conducted over by Mr. Purdon Clarke, the honorary architect of the palace, and by Dr. Tyler, who is in charge of the natives. Sir Philip Cunliffe-Owen, Secretary to the Royal Commission, was in attendance.

RECEPTION COMMITTEE.

After consultation with the Agents-General of the Colonies, the Reception Committee have adopted a classification of the visitors who may be expected to come within the range of their operations, and for whose benefit accordingly special excursions are being arranged. Besides a limited number of representatives of the different Executive Commissions, the classification includes: — Colonial governors, ministers and ex-ministers; members of legislatures; mayors of cities; heads of Government departments; secretaries to the High Commissioner and Agents-General; judges of the higher courts of justice; officers in the colonial forces, who have held command down to, and including the rank of lieut.-colonel; presidents of railway companies; principals of universities; prelates and heads of religious denominations; widows of ex-Governors and Administrators of Governments. The wives and daughters of those visitors who are comprised in the above list will be considered as being included in the classification. The names of distinguished visitors from the Colonies not included in any of the above classes will be added to the committee's list on the recommendation of the Agents-General, and as the arrangements of the committee permit.

PREPARATION OF HIDES IN SOUTH AMERICA.

A Buenos Ayres newspaper calls the attention of stock breeders to the fact that the hides of cattle in many cases lose a great part of their value on account of the careless way in which they are stripped from the slaughtered animal. Calf skins and sheep pelts are often reduced one-half in value by being gashed and improperly stretched. When a hide is stripped off, it should be stretched at once and pegged out to dry, with the flesh side upward. If it is rolled up, thrown into a heap, and left to dry in that shape, it is so mean looking that a buyer will only offer half its real value. A few hints as to taking off a hide will be useful. The skin is slit from the chin down the brisket in a straight line to the tail; it is then cut round each hoof, the hind legs are slit behind over the gambrel, but the front ones are slit up in front over the knees. This leaves the skin in a good shape for finishing the leather. The head and legs are first carefully skinned, taking care to avoid cutting the skin. The skin is then easily drawn off, by taking hold of it firmly and pulling it steadily. It is then spread out evenly on a floor, and sprinkled with fine salt. If there is but one, it is best to stake it out as soon as the salt has taken, and dry at once in a cool shady place. If there are more than one, then they are laid upon each other, and salted freely, and afterwards thoroughly dried. If the skins are to be kept, they should be closely watched for moths or grubs.

General Notes.

PRODUCTION OF CREAM OF TARTAR AT MESSINA. —According to the annual report of the Chamber of Commerce of Messina, it will be seen that a marked increase in the exports of cream of tartar from that port has taken place during the last three years, being as follows:—1883, 3,500,000 kilogs.; 1884, 4,155,671 kilogs.; 1885, 5,721,597 kilogs.

SUBSTITUTES FOR BOXWOOD.—Sir Villiers Lister calls attention to the following passage in Mr. H. Romilly's "Western Pacific and New Guinea" (Murray), p. 136. "The Trisbands . . . . are exceedingly rich islands, and produce various sorts of wood not met with elsewhere, unless perhaps it be on the mainland of New Guinea. There is an extremely hard white-wood which I have never seen except from the Trisbands. It looks almost like ivory when polished, and should be of service for cabinet-making."

DREDGING MACHINERY ON THE PANAMA CANAL.—The machinery employed for the excavation of the canal across the isthmus of Panama is exceedingly powerful. One of the steam dredgers, the "Ferdinand Lesseps," provided with two engines of 250 horse-power each, excavates 22 clopets per day, or 3,300 cubic metres per day, another 800 cubic metres, and an American built one even 1,000 cubic metres per day. Besides these there are a large number of smaller ones in operation, in all capable of excavating 37,000 cubic metres per day, which quantity will shortly be increased, as other powerful machinery has been ordered by the company. During the months of February, upwards of 1,100,000 cubic metres were excavated.

EXPORTATION OF FOWLS FROM ITALY.—Formerly the greater part of the fowls sent to Marseilles was furnished by Gascony and Languedoc; now Italy supplies the greatest number, and chiefly Lombardy. Italian fowls also are sent to Spain. Every Friday a specially constructed live poultry truck arrives at the Marseilles railway-station. It is of similar dimensions to an ordinary covered goods truck, and contains about 3,000 fowls in 108 hen-coops. The truck consists of nine tiers of cages, twelve to each tier, and each capable of holding thirty fowls. Being well ventilated and kept scrupulously clean, and supplied with an abundance of fresh water and millet-seed, the fowls from Milan and even Venice arrive at Marseilles in the best possible condition of health, and large numbers are likewise forwarded to Spain.

MEETINGS OF THE SOCIETY.

ORDINARY MEETINGS.

Wednesday evenings, at Eight o'clock:—

MAY 12.—"The Proposed Fishery Board." By J. W. BUND WILLIS BUND. Sir EDWARD BIRKBECK, Bart., M.P., will preside.

MAY 19.—"Watchmaking by Machinery." By Prof. LEONARD WALDO, D.Sc. of Yale College, U.S.

MAY 26.—"The Purification of Water by Agitation with Iron, and Sand Filtration." By WILLIAM ANDERSON, M.Inst.C.E.

FOREIGN AND COLONIAL SECTION.

At Eight o'clock:—

TUESDAY, MAY 25.—"Cyprus since the British Occupation." By G. GORDON HAKE. Major-General Sir ROBERT BIDDULPH, K.C.M.G., C.B., will preside.

APPLIED CHEMISTRY AND PHYSICS SECTION.

Thursday evenings, at Eight o'clock:—

MAY 13.—"The Scientific Development of the Coal Tar Colour Industry." By Professor R. MELDOLA, F.C.S. Professor JAMES DEWAR, M.A., F.R.S., will preside.

INDIAN SECTION.

Friday evenings, at Eight o'clock:—

MAY 7.—"Indian Manufactures from a Practical Point of View." By B. H. BADEN POWELL, C.I.E. Sir JULAND DANVERS, K.C.S.I., will preside.

MAY 21.—"Everyday Life of Indian Women, as revealed in their own sayings." By Capt. RICHARD CARNAC TEMPLE. JAMES GIBBS, C.I.E., will preside.

CANTOR LECTURES.

The Sixth Course will be on "Animal Mechanics." By B. W. RICHARDSON, M.A., M.D., F.R.S.

Lecture II.—May 10.—Methods of construction, natural and human.

Lecture III.—May 17.—Some details of results of construction.

Lecture IV.—May 24.—Some special Mechanisms.

Lecture V.—May 31.—Mechanisms continued; and Review in regard to practical applications.

ADDITIONAL LECTURES.

The course of Elementary Lectures on "Electricity" will be continued by Professor GEORGE FORBES, on Saturday afternoons, at Three o'clock:—

Lecture VI.—May 8.—Electro-magnetic Phenomena.

Lecture V.—May 15.—Induction.

Lecture VI.—May 22.—Electrical Measurement.

A course of three lectures on "Japanese Art Work" will be delivered by ERNEST HART, on Tuesday evenings, May 4, 11, 18, at Eight o'clock:—

LECTURE II.—MAY 11.

KERAMICS AND LACQUER.—Early Pottery of Japan—The Cup of Taikosama—Tea jars and utensils of the tea ceremony—Blue and white introduced by Shonsui—The influence of individual artists on the varieties of porcelain and pottery—Imari ware of the 17th century—Old Japan ware; its place in Art—The schools founded by Kakiyémon Ninsei, Kenzan—The modern work of Tanzan—Lacquer:—Its beginnings, its technical classification—Work of the 15th and 16th centuries—Schools of Shiounsho, Koma, Kôrin, the Kajikawao—Old lac and modern lac.

LECTURE III.—MAY 18.

PICTORIAL ARTS OF JAPAN.—The Buddhist school—Kanaoka and Chodensu, 9th to 15th century—The Tosa school — Mitsunobo — The Sesshiu school, Doan, 15th and 16th century—Chinese school, Shiubun and Sôtan, 15th century—The Kano school, Masanobu Motonobu and Tanyu, 15th to 17th centuries—Old popular school—Matahei and his followers, 16th to 18th century—Korin and Kenzan school, 17th century—Naturalistic school of Okio, 18th century—Colour prints of the Katsugawa school—Hokusai and his pupils.

MEETINGS FOR THE ENSUING WEEK.

MONDAY, MAY 10...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. (Cantor Lectures.) Dr. Richardson, "Animal Mechanics." (Lecture II.)

Geographical, University of London, Burlington-gardens, W., 8½ p.m. Prof. W. M. Ramsay, "Roman Roads and English Railways in Anatolia."

TUESDAY, MAY 11...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. (Special Lecture.) Mr. Ernest Hart, "Japanese Art Work." (Lecture II.)

Royal Institution, Albemarle-street, W., 3 p.m. Prof. A. Gamgee, "The Function of Circulation."

Medical and Chirurgical, 53, Berners-street, Oxford-street, W., 8½ p.m.

Civil Engineers, 25, Great George-street, S.W., 8 p.m. 1. Discussion on papers by Mr. Francis Fox, "The Mersey Railway;" and by Mr. William Edmund Rich, "The Hydraulic Passenger Lifts at the Underground Stations of the Mersey Railway." 2. Mr. William W. Hulse, "Modern Machine Tools and Workshop Appliances for the Treatment of Heavy Forgings and Castings."

Photographic, 5A, Pall-mall East, S.W., 8 p.m.

Anthropological, 3, Hanover-square, W., 8 p.m. 1. Mr. Francis Galton, "Notes on Permanent Colour-Types in Mosaic." 2. Professor Flower, "Exhibition of a Nicobarese Skull." 3. Professor Macalister, "Some African Skulls in the Cambridge University Museum," and "A New Ireland Skull." 4. Paper by Dr. J. G. Garson.

Colonial Institute, St. James's Banqueting-hall, 69, Regent-street, W., 8 p.m. Mr. W. L. Dobson, "Tasmania as it is."

Horticultural, South Kensington, S.W., 1 p.m. Promenade Show.

WEDNESDAY, MAY 12...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. Mr. J. W. Bund Willis-Bund, "The Proposed Fishery Board."

Geological, Burlington-house, W., 8 p.m.

Shelley Society, University College, Gower-street, W.C., 8 p.m. Mr. Henry Sweet, "The Primitiveness of Shelley's view of nature, its parallelism with that of the Vedas, and its contrasts with that of Shakspere and other poets."

Graphic, University College, W.C., 8 p.m.

Microscopical, King's College, W.C, 8 p m. 1. Dr. G. M. Sternberg, "*Micrococcus Pasteuri* (Sternberg)." 2. Mr. F. H. Evans, "Photomicrography by the Woodburytype Process." 3. Mr. C. D. Ahrens, "New Polarising Prism."

Royal Literary Fund, 10, John-street, Adelphi, W.C., 3 p.m.

Royal Society of Literature, 4, St. Martin's-place, W.C., 8 p.m.

Iron and Steel Institute, 25, Great George-street, S.W., 10½ a.m. General Meeting. Council Report, Presidential Address by Dr. Percy. Reading of papers and discussion.

THURSDAY, MAY 14...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. (Applied Chemistry and Physics Section.) Prof. R. Meldola, "The Scientific Development of the Coal-Tar Colour Industry."

Royal, Burlington-house, W., 4½ p.m.

Antiquaries, Burlington-house, W., 8½ p m.

Iron and Steel Institute, 25, Great George-street, S.W., 10½ a.m. Reading of papers and discussions continued.

Parkes' Museum of Hygiene, 74A, Margaret-street, W., 8 p.m. Mr. R. Warrington, "Recent Investigations on Well Waters."

Royal Institution, Albemarle-street, W., 8 p.m. Prof. Dewar, "The Alkaloids."

Telegraphic Engineers and Electricians, 25, Great George-street, S.W., 8 p.m. Mr. W. H. Preece, "Long Distance Telephony."

Mathematical, 22, Albermarle-street, W., 8 p.m.

FRIDAY, MAY 14...Industrial Villages Society (at the HOUSE OF THE SOCIETY OF ARTS).

United Service Institute, Whitehall-yard, S.W., 3 p.m. Major H. Elsdale, "The Defence of London and of England." (Part II.) "The Successive Stages of the Defence."

Royal Institution, Albemarle-street, W., 8 p.m. Weekly Meeting, 9 p.m. Prof. J. M. Thomson, "Suspended Crystallisation."

Iron and Steel Institute, 25, Great George-street, S.W., 10½ a.m. Reading of papers and discussions.

Quekett Microscopical Club, University College, W.C., 7½ p.m. Exhibition of Micro-photographs with the Lantern, by Mr. F. H. Evans.

Clinical, 53, Berners-street, W., 8½ p.m.

New Shakspere, University College, W.C. 8 p.m. Musical Entertainment. A fourth selection of ballads and songs mentioned by Shakspere, and of Shakspere madrigals, glees and songs, in chronological order, under the direction of Mr. James Greenhill.

SATURDAY, MAY 15...SOCIETY OF ARTS, John-street, Adelphi, W.C., 3 p.m. (Special Lecture.) Prof. George Forbes, "Electricity." (Lecture V.)

Royal Institution, Albemarle-street, W., 3 p.m. Prof. Ernest Pauer, "How to Form a Judgment on Musical Works." (Lecture II.) With Musical Illustrations.

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FRIDAY, MAY 14, 1886.

All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

NOTICES.

CANTOR LECTURES.

Dr. B. W. Richardson, F.R.S., delivered the second lecture of his course on "Animal Mechanics," on Monday evening, 10th inst., in which he dealt more particularly with the materials used by Nature in construction.

The lectures will be printed in the *Journal* during the summer recess.

ADDITIONAL LECTURES.

Professor George Forbes delivered the fourth lecture of his course of elementary lectures on "Electricity" on Saturday afternoon, 8th inst., when his special subject was electro-magnetic phenomena.

Mr. Ernest Hart delivered the second lecture of his course on "Japanese Art Work," on Tuesday evening, 4th inst. The lecturer described the various schools of pottery of Japan, and illustrated these by exhibiting specimens of the work of the great potters. He concluded with an account of lacquer.

The lectures will be printed in the *Journal* during the summer recess.

JAPANESE EXHIBITION.

The Exhibition of Works of Art by the great Japanese masters, ranging from the 7th century to the present date, lent by Mr. Ernest Hart, will remain open daily until Saturday, 22nd inst.

Hours: 10 till 4, and 7.30 till 9.30 p.m.; Saturdays 10 till 2.

Masters and students of schools of art, and the heads of firms of technical art industries (metal-work, carving, pottery, painting, colour-printing, embroidery, &c.), will receive admission for parties on application to the Secretary of the Society of Arts.

A full catalogue of the Exhibition has been prepared, and it was proposed to issue it this week to the members of the Society as a supplement to the present number of the *Journal*. It appears, however, that the interpretation of the Post-office regulations by the officials of that department is such that they would not permit this. Members, therefore, who wish for a copy of the catalogue, are requested to send word to the Secretary, when it will be supplied to them, free of charge.

Proceedings of the Society.

FOREIGN & COLONIAL SECTION.

Thursday, May 6, 1886; Sir Henry Barkly, G.C.M.G., K.C.B., F.R S., in the chair.

The paper read was—

THE INDUSTRIES AND COMMERCE OF NEW SOUTH WALES.

By Edward Combes, C.M.G.

The distinctive character of the Colonial and Indian Exhibition, which was opened the day before yesterday, commends itself in many ways. It has gathered together a display of national wealth from all the outlying territories of the Empire. It will give the British public ample opportunities to study, and examine for themselves, the varied products of those lands, and the workmanship of those people who, while fellow subjects of the Queen of England, reside on the other side of the globe in a country which, less than a century ago, was occupied only by cannibal savages.

All other Exhibitions prior to this have been international in their character. The Colonies and India have been simply fractional portions of the British Section. Here they have to stand alone, and exhibit their strength and resources independently. The Exhibition is replete with interest. We find grouped in one building specimens of the pastoral, agricultural, and mineral wealth of all the Colonies. These show in the most patent manner the unbounded capabilities of the Empire in her Colonies, and cannot fail to produce a good effect in strengthening the bond of union which exists between the mother country and her colonial children. It will also conclusively prove that, should any necessity arise for such action, the Empire has in its own hands, and at its own disposal, all the products and materials to make it self-contained and independent of the rest of the world. It further illustrates in the extent of these vast resources, together with the facility with which they can be produced, that the British Empire has unrivalled qualities and advantages for a successful intercourse and competition with all other nations.

Raw products cannot have the same effect upon the senses as that produced by manufactured articles, and there can be little doubt that the shawls and jewellery of India will be more interesting to the general public than the wool, grain, and minerals of the Colonies. Nevertheless, to commercial men and political economists these natural products must be intensely interesting, as they indicate greater national expansion and increased national greatness. These resources are now brought prominently before the British public, together with examples of the ingenuity and skill of the population, and will also prove that were the Australian Colonies condemned to self-support, they would still be in a position to supply themselves with everything necessary to develop and advance Australia to the highest stage of civilisation.

In taking this opportunity to give some detailed information upon the industries and commerce of New South Wales, I am acting in strict accordance with an expressed invitation of the Committee of the Society of Arts. I must, however, crave your patient indulgence as—of necessity—I shall have to make my paper little more than a compilation of statistics. These, for future reference, will be interesting and useful, but I feel they are very dry matter upon which to lecture. As, however, all the dependencies of the Empire have, through the instrumentality of the Exhibition, been brought into such close relation with the mother country, it is possible at this particular moment the statistics I have got together will not be unfavourably received.

It will be needful, in introducing the subject, to make a few remarks upon the country itself, which has in so marked a manner pushed itself forward before the whole world, and shown itself to be a young, vigorous, and worthy offshoot of that great and illustrious Empire of which we are all so justly proud. I must be permitted to make a few comparisons as to the size of Australia relatively to that of other and better known countries, in order that you should thoroughly understand how vast is the expanse of that southern territory which belongs to the British Empire. First, then, I may say, the mainland of Australia lies between the parallels 10° 39′ and 39° 11½′ S. lat., and the meridian 113° 5′ and 153° 16′ E. long. Its greatest length is from west to east, and is about 2,400 miles; whilst its greatest breadth is north and south, and is about 1,971 miles. Its area is computed at 2,944,628 square miles, or 1,884,561,920 statute acres; or, including Tasmania and New Zealand, 3,075,406 square miles, or 1,968,259,840 acres. It is about twenty-six times the size of Great Britain and Ireland, fifteen times the size of France, about one-sixth smaller than the whole of the United States of America, and only about one-fifth smaller than the whole continent of Europe. It is bounded on the north by Torres Straits, the Gulf of Carpentaria, the Arafura Sea, and the Indian Ocean; on the east by the South Pacific Ocean, on the south by Bass's Straits and the South Pacific Ocean, and on the west by the Indian Ocean.

To convey a general idea of the location of the different Colonies, we may divide the mainland into three parts by lines running north and south. The western part consists altogether of Western Australia; the central, of South Australia and its adjoining northern territory; and the eastern, of the Colonies of Queensland, New South Wales, and Victoria. If we suppose the whole of Australia divided into a hundred parts, then Western Australia would represent 34, South Australia 30, Queensland 23, New South Wales 10, and Victoria 3 of such parts.

Its physical features are characteristic. Eminent geologists have described it as an immense plateau with a narrow strip of land between the elevated portion and the sea. The eastern side is the highest, as, at a distance varying from twenty to a hundred and twenty miles from the coast, there is a cordillera or mountain chain forming a great dividing range, separating the eastern from the western waters, rising at the south-east angle of the continent to over 7,000 feet in height. At the point where the Great Western Railway crosses these mountains, the summit level is attained at an elevation of 3,678 feet, and the average height is much greater than the high land on the western side of the continent, which probably averages about 1,000 feet above the sea level. The land slopes rapidly away from this "great divide" towards a central depression, which is south and east of the true centre of the continent. The base of all this table-land of Australia is granitic, and isolated mountains of granite crop out throughout the whole of the western interior. It forms the axis of the Australian Alps. There are, however, considerable tracts of country in which the granite is replaced by upturned palæozoic strata, mostly in the form of slates and schists, with an almost vertical dip. Above the older of the palæozoic rocks and granite are certain basins of coal-bearing rocks belonging to both the mesozoic and palæozoic periods. These are mostly found on the eastern side of the table-land, but possibly they may be only thinly covered elsewhere, and that a most extensive coal-bearing area may be found on the western slopes in the same latitude. Over the coal measures on the edge of the table-land, all round the continent, there is a horizontal sandstone formation, with oblique laminations. There are two formations of granite. That which forms the central axis of the table-land has a peculiarity which differs from the outer parts of the granitic axis in this, that it is rich in mineral veins. It is in such formations that the valuable deposits of tin are found; they also contain veins of silver, lead, and copper, and a considerable quantity of alluvial gold is scattered in various localities. The largest quantities of Australian tin are found in the alluvial workings, and consist of tin ore, washed out of the granite by streams, and deposited in their beds. True veins or lodes of tin are also found in the granite.

In connection with the granite, the slates and schists of the Cambrian and probably Laurentian periods are found. These contain the lodes, or veins, which produce gold and other metals, and chiefly consist of quartz. Gold is not often actually embedded in the quartz, but in small cavities, and in laminations, and is often accompanied with iron pyrites. Very rich copper veins have also been found in rocks of this period, as well as many other metallic minerals of silver, bismuth, antimony, lead, and manganese. Devonian rocks with characteristic fossils, often identical with those of Europe, are found very extensively developed in various parts of the continent. In connection with the upper Devonian system, we have metaliferous veins of gold, copper, and other metals. For instance, at Gympie, in Queensland, the gold mines are of great richness.

The Rev. J. E. Tenison-Woods has expressed an opinion that Australia has had little participation in the great ice age. He says there have been a few recorded instances of grooves or striations, but these standing alone in so vast a territory, makes their ice origin very doubtful. On the whole, the evidence afforded by the animal remains is decidedly in favour of a warmer climate for Australia than that which now prevails, and this is borne out by the plant remains. While the south portion of the continent was slowly submerging under the tertiary sea, there is every reason to believe that the eastern side of the continent was raised above the sea level. The period of this elevation must have been subsequent to the cretaceous, as marine fossils of that period are found on both sides of the watershed and on the table-land. There are no marine tertiary beds on any portion of the eastern side of the continent, except a few post-tertiary marine shells preserved in ash beds, and are only seen where deposits have been dammed back by a bank of volcanic mud. On the whole eastern side of Australia, and also in many parts of the south, there are instances where vegetable remains are found in the old drainage channels covered by lava streams. They show a remarkable series of fruit-bearing trees, different from those which occupy the same areas at the present day. No conclusion could be drawn from these remains as to the age of the beds, but as they were identical, when found in widely separated plains—sometimes 600 miles apart—it was seen that a flora existed all over the table-land which has now disappeared. Mr. Tenison-Woods goes on to say, that the most recent of all Australian formations are the raised beaches and the various drifts and æolian formations throughout the continent. The raised beaches are confined to the south side of Australia, as far as has been observed, and are of limited extent. The drifts are more extensive, and were probably deposited at different times and under different conditions. Such formations are extremely important, as they contain the remains of those strata which denudation during immense geological periods have left behind. Thus they retain the gold which has been derived from the Cambrian and silurian rocks. Wherever these drifts are found overlying auriferous quartz veins, they are also rich in alluvial gold, and have proved the richest deposits in the Colonies, besides being the source of all those large masses of gold which are called "nuggets," models of which you can see at the Exhibition, many of which have been of great size and weight. The alluvial is shallow, and, as a rule, easily worked; but there are many instances where it has been covered with thick outpourings of lava of 300 and 400 feet in thickness.

The central depression in the continent must, from its structure, be an immense reservoir of water, as the rainfall is largely in excess of the river drainage, and on this account exceedingly favourable to the formation of artesian wells. Attention was drawn to this by Mr. Tenison-Woods in 1863, and it has lately been tested and found that his predictions were correct. One fact alone in the physical structure of the continent should have indicated such stores of water in the interior. In the central depression there is a line of groups of thermal and cold water springs, covering several hundreds of square miles. These send forth water from great depths, and are, no doubt, derived from a central underground reservoir whose sources are on the slopes of the table-land. That the waters come from great depths is seen from the temperature, and the mounds of sinter, or travestine, around them. This, no doubt, is the silica, &c., once held in solution by the thermal waters under pressure, but liberated on arrival at a level where the pressure was removed. In the mounds are found deposits of bones, teeth, and other remains of those gigantic marsupials which once roamed over Australia, but which are now totally extinct. We find also the remains of extinct crocodiles even within the limits of New South Wales, as well as gigantic lizards, tortoises, &c. The largest of our extinct marsupials, the *diprotodon*, must have been as large as an elephant, and the abundance of its remains in almost every cave and river bed, shows that it was very numerous and wide-spread. Its disappearance from the continent was in very recent times. In 1866, Mr. Tenison-Woods says he found the remains of a struthious bird, much larger than the emu, in one of the kitchen middens of the aborigines in South Australia. The bones were marked by the scrapings and cutting of the flint knives of the blacks. It has since been named *Dinorsis Australis* by Professor Owen, who has found that the bird had formerly a wide range in Australia. I have thought it necessary to dilate somewhat upon the physical structure of Australia, as it is so intimately connected with one of our chief industries, of which I shall speak hereafter, and in speaking generally of the entire continent to show the enormous field which exists for extensive mining enterprise in the future.

The colony of New South Wales originally consisted of the whole of the eastern portion of Australia, including Victoria and Queensland. Captain Cook, the illustrious navigator, discovered this land in 1770, and formally took possession of the continent for his Majesty King George III., calling it New South Wales, and from the favourable report he gave of Botany Bay it was decided by the British Government to occupy it chiefly with the view of making it a place for the transportation of convicts. In a paper I read before the Royal Colonial Institute, on the 8th of December last, I pointed out the fact that almost immediately after the United States of America had declared their independence, Pitt, who was then Premier of England, decided upon the occupation of New South Wales. In all probability he was primarily led to do this in order to secure a suitable place for the deportation of criminals. The American Colonies, which had so long been the receptacle of convicts, could no longer be used for this purpose. I cannot, however, but think that his genius pointed out the enormous advantages that would accrue to the British Empire, by having, in the South Seas, such a splendid "Greater Britain," with a territory nearly as large as the Continent of Europe. He knew—none better—that the ever-increasing population of England would soon require more room than the British Islands could afford to give, and that it would be far better for such surplus population to occupy and improve a land belonging in fee simple to their own nation, than to populate and aggrandise the United States of America. The genius of Pitt—had he lived twenty years ago—would doubtless have pointed out to the British public that it was the part of a good parent to assist in constructing the bridge, so to speak, to connect the mother country with her great southern possessions. Even this illustrious statesman, however, could not have supposed, at the time he sent out the first fleet under the command of Captain Phillip, that within a century from that period, the United States, which then only numbered some four millions, would have increased to over sixty millions, that the Canadian Colonies would number another five millions, while the colony he was about to establish would have become a group of separate states, self-governing and free, with a population of over four millions, and a revenue of £25,000,000—larger than that of the Kingdoms of Belgium, Denmark, and the Netherlands together.

Surely this marvellously rapid progression shows the necessity of doing everything possible to preserve the unity and integrity of this glorious Empire. What has already been done in the rapid increase of the English-speaking race will be again repeated, only far more rapidly than before. The British Islands had, a hundred years ago, only a little more than half the population they have now; but since that period the English-speaking race have more than quadrupled. The people are still as full of vitality and as prolific as ever, while the increase must go somewhere. The stream of continued English and European emigration must, in the course of a comparatively short time, be diverted from the United States to Australia. Then the population will increase with giant strides, and upon the foundation which has been so well and truly laid by those pioneers who have fought and toiled for the dearly treasured institutions of freedom and self-government, will be raised a superstructure fitted to take its place by the side of its parent, and worthy of the nation from which it has sprung.

It is with the mother colony of Australia that I have to deal to-night, and in a few words I shall dispose of the peculiar physical features which belong to her, and which undoubtedly have the greatest influence upon her industries. Shorn of her original dimensions, which included, as I have before stated, the whole of the eastern portion of Australia, it is now restricted to less than one half, and lies between the 28th and 37th degrees of S. lat., and the 141st and 154th meridians of E. long. On the east it is bounded by the Pacific Ocean; on the South it is separated from the colony of Victoria by a line drawn from Cape Howe to the nearest source of the Murray, and by the westerly course of that river; on the west it is separated from South Australia by the 141st meridian of E. long., and on the north it is separated from Queensland by the Macpherson Range, the Dividing Range, the Dumeresq River, the Macintyre River, and the 29th parallel of S. lat. Its greatest length is about 900 miles, and its greatest breadth about 800 miles, while its computed area is 197,872,000 acres, or nearly equal in extent to that of the United Kingdom and France combined. The cordillera before alluded to forms a great dividing range separating the eastern from the western waters. The Murray River receives many of its tributaries from the colony of Victoria, as well as from New South Wales, while the Darling and its tributaries dispose of the remainder of the western watershed. The Darling joins the Murray near the South Australian boundary, thus all the drainage of the vast area of western New South Wales is carried to the sea by the River Murray. The surface of the colony may therefore be divided into what may be considered the coast and mountainous district, the north and south table-lands and western slopes, and the great western plains of the interior. The seaboard districts are well watered, and with a large proportion of good land adapted to all kinds of agriculture. The central portion has also immense tracts highly suitable to the cultivation of cereals, while the far west is specially adapted to pastoral enterprise, where millions of sheep, cattle, and horses are bred, reared, and fattened upon the natural grasses of the country.

The climate of New South Wales approximates to that of Southern Europe as it situated in the temperate zone. Within the boundaries of the colony, however, there are many varieties of climate, but the range of the thermometer is far less than within the same parallels of latitude in the northern hemisphere. It is exceedingly healthy, with clear air and plenty of sunshine. The mean annual temperature of Sydney is 62·6° Fahrenheit, or about 4° above that of Paris, while the mean temperature of the whole colony is 59·5°. In its vital statistics it compares favourably with most parts of the world, and instances of great longevity are numerous. Births per 1,000 of mean population in 1883, averaged 37·09 per cent.; deaths, 14·52; and marriages, 8·78. The excess of births over deaths amounted to 158·38 per cent. The greatest heats are in December and January, and the greatest cold in July and August. In 1884, the total rainfall at Sydney was 44·040 inches, and the mean temperature of the year 63·2. Although many tropical plants grow in the Sydney Botanical Gardens, a five hours' railway journey to the westward brings about a great change. At Mount Victoria we have an elevation of 3,500 feet above the sea level, where gooseberries, raspberries, currants, and all kinds of English fruit are cultivated with success. The temperature of the coast district is influenced, and to a considerable extent equalised, by one of the great ocean currents which begins somewhere to the north of Australia, and has a steady set south, with a velocity of from one to two miles per hour, at a distance of four or five miles from the coast. This stream of warmer water acts in a similar manner to the Gulf stream which impinges upon the British Isles, and exercises a similar beneficial influence upon the climate.

New South Wales has been furnished by nature with an excellent soil and a fine climate, capable of growing food for many millions. A considerable portion is covered with timber, chiefly of the eucalyptus order, and known as the gum tree. There are twenty-seven varieties, most of which produce good timber for building purposes, and some, such as stringy bark, the red and blue gum, iron bark, and several others, are equal in quality to the oak and ash of England. There are over a hundred varieties of acacia, mostly known as wattle trees by the colonists. The cedar tree is becoming somewhat rare, as its home on the deep alluvial flats of the eastern rivers has been invaded by thousands of colonists. These flats were rapidly taken up for agricultural purposes, and the process of clearing, added to the great value of cedar timber, led to its wholesale destruction. Casuarina, banksias (honeysuckle), fig-trees, cabbage palms, with ferns in endless variety make up the *ensemble* of an Australian forest.

The aborigines are fast disappearing, and will in a comparatively short period become as extinct as the *Dinorsis Australis*. According to the report of the Protector of Aborigines there were, in 1884, about 8,000, including half-castes.

Nearly all the animals of New South Wales are marsupials, that is, they have an exterior pouch in which they carry their young. The largest are the kangaroo, and of these a great variety exist. They are found more or less plentiful all over the colony, sometimes in such numbers as to seriously interfere with pastoral pursuits, eating the grass which would depasture thousands of sheep and cattle.

In all new countries the pastoral industry is of necessity the first to develop itself. With an abundance of natural grasses and herbage, and a scarcity of labour, stock raising is found to be the easiest way of making the produce of the soil remunerative. In such a country as Australia, with an area comparatively unlimited, this could hardly fail to be successful, and statistics fully bear out that pastoral pursuits have, first and last, been the largest factor of Australia's commercial prosperity. The stock landed by the first fleet, in 1788, consisted only of a bull, four cows, and a calf, one stallion, three mares, and three colts, with a few coarse-woolled sheep, pigs, and goats; while in 1885, ninety-seven years later, there were 9,000,000 horned cattle; 1,300,000 horses; 80,000,000 sheep; and 1,000,000 swine. It will be interesting to trace the development of this industry, together with the cultivation of the land during the periods of office held by the early governors, as the population and numbers of live stock, together with the acreage in cultivation, will fairly indicate the progress of Australian discovery and civilisation.

In 1792, at the period Captain Phillip left the colony, the number of live stock was 182, and the total quantity of land cleared 1,703 acres, of which 1,540 were in cultivation.

Governor Hunter left the colony in 1800; the live stock had then increased to 13,570. There were 203 horses; 1,044 cattle; 6,124 sheep; 4,017 pigs; and 2,182 goats. There were also, at this time, 7,677 acres of land in cultivation, besides a quantity of garden ground in potatoes and vines. The population was 6,508.

Governor Philip Gidley King left in 1806, and we find that at this period the live stock consisted of 438 horses; 3,264 cattle; 16,501 sheep; 14,300 pigs; and 2,900 goats. The population had also increased to over 9,000; and the quantity of land under cultivation to 12,860 acres.

Lieutenant-Governor Foveaux, immediately prior to the advent of Governor Macquarie at the end of 1809, made the progress of the colony, twenty-one years after being founded, to be as follows:—941 horses; 5,233 breeding cattle; 3,771 oxen; 33,257 sheep, of which 22,451 were ewes; 2,975 goats; and 19,368 pigs; with 11,900 acres of land in cultivation, and the population 11,590. At the end of Macquarie's government, in 1821, the number of horses had increased to 4,564; horned cattle to 102,939; sheep, 290,158; pigs, 33,906; while the population was 38,778, and land in cultivation 32,267 acres.

This was the progress made in cattle breeding and agricultural industry during the first thirty-four years of the colony's existence. Retarded by constantly recurring difficulties, privation, starvation, and Governor Bligh's tyranny, all had failed to discourage that true colonising spirit which so eminently distinguishes the Anglo-Saxon race. With the third of the first century we may conclude that the pastoral industry had been fairly established, and it will be now for us to consider the improvement made in wool-growing, and the system which obtains at the present day.

In the first place it was by an accident that fine-woolled sheep ever got to the colony. It happened thus. The King of Spain presented some fine-woolled sheep of the celebrated Escurial breed to the Dutch Government, and some of these became the property of Colonel Gordon, an officer in the Dutch East Indian Service. After his death, these sheep were sold by his widow, and twenty-nine of them found their way to Sydney on board the *Reliance* and *Supply* frigates. These vessels had just at that time arrived at the Cape for the purpose of taking supplies to Australia. On their arrival at Sydney, Captain John Macarthur purchased as many of them as he could—viz., three rams and five ewes; the rest were distributed to other breeders.

It is chiefly to the energy, skill, and intelligent forethought of this gentleman that New South Wales, and, in fact, the whole of Australia, owes its remarkable success in the production of fine wools. He realised at this early date the vast capabilities of the country for pastoral pursuits, and, fortunately, possessing the nucleus of a stud flock from these Escurial sheep, he devoted himself to the realisation of the great object of supplying the English market with fine wool. He made considerable progress, and in the beginning of the year 1804 we find him in England, laying his plans before the British Government. We will tell the story in his own words. He says "that some of the eminent manufacturers of woollen cloth in England saw by accident some specimens of the wool I had raised in New South Wales. Its qualities were so fine that it induced them to find me out, and to make particular inquiries how and in what manner the wool had been raised. On my communicating to them all I knew upon the subject, they expressed a decided opinion that the colony of New South Wales might, with proper encouragement, be enabled in time to supply the woollen manufacture of England with the whole quantity of fine wool which was then with great difficulty obtained from Spain; and such was the importance they attached to this, that they signified their determination to communicate their opinion to Government by memorial, which was soon afterwards done. In consequence of these memorials being sent in, I was directed to attend a Privy Council, before whom I was particularly examined as to the state of my flocks, and their probable improvement. The Privy Council were so satisfied of the importance of the undertaking, that they recommended to the Secretary of State that it should be encouraged, and Lord Camden was pleased to order me a grant of 5,000 acres of land, in a particular situation which I had pointed out to his lordship; at the same time he wrote to the Governor of the colony that I was to be supplied with shepherds." It may be said that Mr. Macarthur was again favoured by accident; but if he had not succeeded in raising the fine wool which attracted the attention of the manufacturers, no such accident could possibly have occurred. Mr. Macarthur had only three rams and five ewes from the original twenty-nine fine-woolled sheep, the remainder were distributed to other sheep farmers. It was, however, only Mr. Macarthur, whose sagacity led him to keep the blood pure, who achieved success, for ten years later we find this fine strain of blood had entirely disappeared, excepting in the flocks of this gentleman. He afterwards purchased other sheep from the flock of King George III., and thus the growth of fine wool was established.

At this period, looking back, it might probably be thought an easy matter to have started this industry, but in point of fact Macarthur's difficulties were innumerable. So late as 1818, he writes in almost a despondent manner, "my feeble attempts to introduce Merino sheep still creeps on almost unheeded, and altogether unassisted." That he eventually overcame all obstacles, and that wool became the general and great staple of Australia, are matters of history. That it still continues to be its largest export is a matter of fact, for the Australian pastures are still unrivalled for the growth of the finest wool. Careful breeding modified the original type of sheep, and developed the present New South Wales merino, which for marvellously fine wool stands pre-eminent. This is no empty boast, for at the French International Exhibition of 1878, the *Grande Medaille d'Honneur* was decreed to New South Wales, in competition against the whole world.

At the present time wool growing is carried on in a very different manner to that which formerly existed. The improvements chiefly consist in fencing in the runs with iron wire fencing, subdividing the area thus enclosed into paddocks, and providing permanent water by means of wells, dams, and reservoirs. These necessitate a large outlay of capital, but when once effected, the expense of labour in looking after the sheep is reduced to a minimum. Shepherds are no longer employed, and the sheep are permitted to roam at large within their paddocks. They are never folded at night, and only mustered for drafting, shearing, weaning, and branding. Sheep washing, preparatory to shearing, is far less common than formerly, and the sheep are, for the most part, shorn in the grease. Roaming at will, sheep thrive wonderfully, and all the attention they receive or require is to see the fences are in good repair. This is performed by men on horseback, who are called boundary riders, and who carry with them the simple implements they use for making the necessary reparations where required. Setting poisoned baits to kill the dingoes, or native dogs, and large birds of prey, is also the work of the boundary rider. With the improvements I have mentioned, the vast western plains, formerly regarded as waterless deserts, have been made productive. The actual locality where Bourke and Wills lost their lives, in their endeavour to cross the continent, is now a thriving sheep station, and the time is not far distant when the whole of this outside country will be utilised, as it has been proved beyond a doubt that, with properly constructed reservoirs, permanent water can be stored in the driest and most arid parts of the interior.

Wool is the most profitable product of the pastoral interest, and the improvement of stock by more careful breeding, the further subdivision of paddocks and construction of water reservoirs, will necessarily improve its quality and increase its production.

The rapid development of the pastoral interest is shown by the following figures, giving the number of sheep in the colony during each of the years from 1861 to 1883. The figures are taken from the returns issued under the Sheep Act, and are as follows :—

Year.	No.	Year.	No.
1861	6,119,169	1873	18,990,595
1862	6,550,896	1874	22,797,416
1863	7,169,126	1875	25,353,924
1864	9,082,463	1876	25,269,755
1865	9,650,106	1877	21,521,662
1866	11,644,593	1878	25,479,484
1867	15,066,377	1879	30,062,910
1868	16,000,090	1880	35,398,121
1869	16,848,217	1881	36,591,946
1870	16,218,825	1882	36,114,814
1871	16,766,012	1883	34,418,488
1872	17,873,696		

The diminution in the number of sheep during 1882 and 1883 is explained by the large number forwarded to newly opened pastoral districts in other colonies, especially Queensland, and owing to the late severe droughts.

The number of sheep in the colony increased from 6,119,162 in 1861 to 35,000,000 in 1885, and the value of the export of wool in 1883 amounted to £9,598,761 sterling.

Cattle and horse breeding are also large industries. Of the former the colony contains about 1,500,000, and of the latter about 350,000. There is also an immense trade done in hides, leather, and tallow.

The following returns show the progress and resources of New South Wales in the matter of horses, cattle, and pigs :—

	Horses.	Horned Cattle.	Pigs.
1851	116,397	1,375,257	65,510
1861	233,220	2,271,923	146,091
1871	304,100	2,014,888	213,193
1881	364,306	2,182,226	308,205
1882	328,026	1,859,985	154,815
1883	326,964	1,646,753	189,050

I may be here permitted to point out the practicability of supplying the deficiency that exists in the meat markets of England and the Continent by means of the freezing process, which has been practically proved a complete success beyond all dispute. The increased consumption of meat in Europe is not only attributable to the increase of population, but in a higher degree to the increase of wages paid to the artisan and labouring classes, which enables them to purchase more animal food. This deficiency amounts in the United Kingdom to 650,000 tons, and on the Continent to 143,000 tons, making a total of 793,000 tons, a quantity, moreover, which must go on steadily increasing. The difficulties of transit having been overcome, it only remains to develop the trade. The industry is comparatively a new one, but the great fact is, that its object has been successfully accomplished, and simply resolves itself into the price of coal. Steam power is indispensable to almost every industry, and at the present time about seventy horse-power will produce sufficient cold to insure the perfect condition of 10,000 carcases of mutton during the journey from the antipodes to the shores of Great Britain. The frozen meat trade is, doubtlessly, destined in the future to become as large a factor in the production of colonial wealth, as the wool trade is in the present. If required, Australia and New Zealand could furnish a practically unlimited supply at a price which everyone could afford to pay.

In agriculture proper, the cultivation of cereals comes first. The climate possesses special advantages, and is highly favourable to the growth of good wheat. For this purpose the high lands of the colony are the most valuable, and in the Bathurst, Orange, Goulburn, and New England districts, situated from 2,000 to 3,500 feet above the level of the sea, this suitability is most apparent and the largest areas are under the plough. The soil varies according to its situation, but the best for the growth of cereals is to be found in the extensive western country, where the country is volcanic, and where the decomposition of the basalts has formed a rich virgin soil that will carry a succession of good crops for at least thirty years.

Everything that can be grown in England can be grown in New South Wales, and I have known the potato to give heavier crops than have ever come under my notice either in England or America. I have seen thirty tons, but twelve to fifteen tons to the acre are not at all an uncommon yield. Sorghum and the various sorts of imphee are grown chiefly as forage plants, and not the purpose for which they are usually cultivated for in America, viz., the production of syrup, which is so largely used by the farmers and country people instead of sugar. Wheat, barley, oats, and maize are, however, the principal crops. The latter is grown on the deep alluvial river flats, and produces heavily. Its cultivation is easy, and the yield sometimes as high as 100 bushels to the acre for the first crop. Large quantities of maize are exported to the other colonies.

The agricultural returns for the year ending 31st March, 1885, shows that there were 43,079 owners of land over one acre—exclusive of those occupying lands for pastoral purposes—holding 31,353,991 acres of freehold, and 3,681,512 of leasehold land, of which 852,017 acres were under cultivation; 4,968,256 acres were enclosed, but not under cultivation, and the remainder was unenclosed. With such an expanse of good land as exists in the colony, agriculture must steadily go ahead, for in no part of the world are there such facilities for the labouring man to provide himself a home, and to become a flourishing well-to-do farmer.

The cultivation of the sugar-cane is limited to the north-eastern river banks and brush lands. The acreage under cane increases year by year, but the low price of sugar sadly retards the progress which would otherwise be made; but on the Clarence, Richmond and Tweed rivers the industry shows that it must eventually become one of the most important. The Colonial Sugar Company, having recognised the facilities which the land abovementioned afforded for cane-growing, offered liberal inducements to the farmers of the locality for growing cane, and to further this, erected mills and sugar works to crush the cane and for the conversion of the juice into sugar; the company thus providing a market for the smallest growers by purchasing the cane by weight. The variety known as "ribbon cane" is the one usually planted, but as this takes two years to mature, and is more costly to cultivate, the annual varieties are being experimented upon. The crop may be averaged at about 30 tons of the "ribbon cane" and 20 tons of the annual sorts. The farmers contract to supply cane from a certain area for a stated number of years, the company taking delivery of the standing crop in the field and paying the farmers 10s. per ton for growing. The farmers can—if they wish to do so—make arrangements to cut and cart their own cane to the mills, for which they are allowed an adequate remuneration. Land suitable for cane cultivation is very valuable, and tenants give as much as from £2 to £3 per acre annual rent. Most of the farmers, however, own the land they cultivate. The crushing season commences in July or August and lasts until Christmas. The raw sugar is taken to the company's refinery in Sydney, where it is refined and rendered fit for the market. These sugar works are very extensive, and sugar is made equally good in colour and quality with the best kinds imported from Europe.

Tobacco grows luxuriantly. All varieties thrive, from the high-priced Cuban, which I have grown myself on the Lachlan River, and had made into excellent cigars, to the coarse Virginian sorts, which are usually grown for the purpose of manufacturing the ordinary plug and cut tobacco. Its successful cultivation depends greatly upon the seasons, especially at the time when planting out takes place; the plants are raised in seed beds and planted out like young cabbage plants. Should the weather be very dry at this time, hand watering is absolutely necessary, or the crop is lost. At present tobacco growing is mostly in the hands of the Chinese, whose skill and patience in the matter of small cultivations are proverbial. These men manage to raise good crops, and also to destroy the grubs which eat holes in the leaf and so sadly deteriorate the quality. There are fourteen tobacco manufactories in the colony, and a great improvement has been made in the quality of their productions.

Australian wines have already made themselves a name, and the culture of the vine for wine-making should extend rapidly. The vine required no adventitious aids in its acclimatisation. It took to the Australian soil as naturally as young ducks take to the water. It grows almost anywhere, bears a large quantity of fruit, and in certain districts, such as the Hunter and Murray, vineyards are becoming numerous, and planted with choice varieties for wine-making. At all the international exhibitions in England and Europe, and notably those at Paris in 1878, and subsequently at Bordeaux and Amsterdam, New South Wales wines took an excellent position in competition with European productions. M. Bonnard, who had charge of the exhibits at Bordeaux and Amsterdam, says in his report that "Australia possesses a climate and soil which permits its people to grow wine of the quality required by European consumers, and in sufficient quantities to enable it, within the next ten years, to flood every part of Europe with its produce, so that it would be as strange to find a place without a cask of Australian wine as it would be to find a wool factory without a bale of Australian fleeces." He goes on to say that, in his presence it had been admitted by Europeans, that wines had been produced "of as good quality, and far better in other and numerous instances, than many wines produced in Southern Europe, or to be had even in France." Sir William Macarthur, of Camden, spent much time and money in the introduction of wine-producing vines, and Mr. Bushy, so long ago as 1831, collected a valuable assortment of plants in France and Germany, which he planted at Kirkton, on the Hunter River, and established the first vineyard planted in the district. So well adapted are all the circumstances required for the production of wine, that the cultivation of the vine is comparatively easy and profitable, and the smallest grower can make the business remunerative. Statistics point out that in France alone, the total requirements of the wine trade are 902,000,000 gallons in excess of the French production (the figures are M. Bonnard's), and that not only is the consumption of wine yearly increasing all over the world, but the European supply is yearly decreasing. The total production of wine in France in 1875 was 1,844,400,602 gallons, which was in 1884 reduced to 751,051,730 gallons. Surely here is an opening for a great trade, as there is a market in France alone for hundreds of millions of gallons of imported wines.

I am fully aware how difficult it is to educate the people of England in all that pertains to the appreciation of pure, light, wholesome wines. The national taste has been vitiated by the common use of strong, heady, and sweet adulterated wines, and it is not until the appetite for such strong drink ceases to exist that a love for the pure juice of the grape is engendered. M. Bonnard suggests that, in order to place Australian wines in their proper position in the markets of Europe, and to enable the growers to dispose of them at remunerative prices, they should be placed upon these markets by the proprietors themselves in the following manner:—A syndicate of wine growers should be formed in Sydney, having special depôts in London, Havre, and Antwerp, until these countries were familiarised with the names, merits, and values of the wines. They would then be so well established, that the European consumers and Australian growers could be brought into direct contact, and conduct their own business without having to fear the influence of prejudices or the conspiracy of a ring, merely employing sworn wine brokers in the usual way, for their mutual satisfaction. He also thinks that the cost of producing wine in the colony is not greater than that at Bordeaux, and the expenses of freight and charges not much in excess of what is actually charged on the wines brought from Hungary, Sicily, Italy, Portugal, or Spain.

With such advantages in soil and climate, it may, I think, be safely predicted that before many years the wines of the colony will occupy a high position among the exports of New South Wales.

I must not leave the subject of agriculture without saying a word with reference to the occupation of the Crown lands of the colony. To fully deal with this matter, I cannot do better than to give a short digest of the Act which came into operation at the beginning of last year, and which divides the colony into three divisions, eastern, central, and western. The eastern division comprises the coast district from Point Danger on the north to Cape Howe on the south, and has been roughly estimated to comprise about 61,440,000 acres. The central division has been similarly estimated to comprise about 58,880,000 acres. The western division has been similarly estimated to comprise about 80,000,000 acres. These divisions are accurately described in the schedule to the Act.

Crown lands (irrespective of sales without competition in certain special cases) can be obtained in either of the following ways :—

1. Conditional purchases, including the right to acquire additional conditional purchases.
2. Conditional purchase without residence.
3. Conditional lease.
4. Auction.

All grants under the Act will contain a reservation of minerals, and all alienations are subject to special provisions as to the auriferous portion thereof.

Crown lands (with certain exceptions, such as those which are under lease, or within leasehold areas, or reserved for any purpose, or dedicated or situated within population areas, or in occupation for mining purposes, or containing improvements) are open for conditional purchase in the eastern and central districts, but not in the western (unless within special are as proclaimed), subject to certain provisions as to measurement, form, &c., in quantities as follows :—In eastern division, 40 and not exceeding 640 acres ; in central dlvision, 40 acres and not exceeding 2,560 acres. By Section 24 certain provisions are made for special areas in all three divisions. The applicant must be sixteen years of age or upwards, and must make his application in person. The application must be accompanied by a deposit of 2s. per acre. Within three months of confirmation of application by the Local Land Board he must commence and continue *boná fide* residence during five years. He must fence within two years of confirmation, but this period may be extended on cause shown. Within three months of third year, after confirmation, he must pay 1s. per acre, and thereafter pay a like instalment annually until the balance of 17s. per acre, with interest at 4 per cent. per annum, shall be paid. At the expiration of the third and fifth year he must make declaration of fulfilment of conditions as to residence and fencing. At the expiration of fifth year (conditions of residence, and fencing, and of payments of instalments to date, being complied with to the satisfaction of Local Land Board) a certificate will issue, indicating *primá facie* ownership, subject to payment of balance of purchase-money, and grant will issue on payment of the latter. Conditional purchases, original or additional, may be transferred after completion of residence, but are liable to forfeiture on non-compliance with any of the conditions, or on false declaration. No person shall make more than one conditional purchase (except by way of additional conditional purchase) until certificate of complete fulfilment of conditions, except payment of balance. Holders of conditional purchases not exceeding in eastern division 600 acres, in central division 2,520 acres, may make additional conditional purchases adjoining their holdings (subject to certain provisions as to measurement, &c.), provided same with their original purchases do not exceed the extreme limits of 640 acres in the eastern and 2,560 acres in the western division respectively. Applicants of the age of twenty-one and upwards may apply for Crown lands, without conditions of residence, in quantities of 40 acres and not exceeding 320; the deposit and other payments are double those in the case of conditional purchases proper, the fencing must be performed within twelve months, and £1 per acre must be expended in improvements other than fencing before certificate of fulfilment of conditions can issue. No purchaser under this head shall be permitted to make any other conditional purchase, and *vice versâ*. An applicant for a conditional purchase (with residence) in the eastern division (except in special area), and any applicant for a like purchase in the central division, may apply for a conditional lease of land adjoining his conditional purchase, not exceeding three times the area thereof, if available. The area of the entire holding, however (both purchased and leased), must not exceed, in the eastern division, 1,280 acres ; in the central division, 2,560 acres. Rent, not less than 2d. per acre, to be fixed by the Local Land Board, subject to approval of Minister. The lessee, at expiration of five years, to have preferent right, under certain conditions, either of extending the term for another five years, or of conditionally purchasing the whole or any portion (being not less than 40 acres) of the area in such conditional lease adjoining his original or additional purchase, free from condition of residence. Fencing and residence conditions same as in case of a conditional purchase ; residence may either be on the conditionally purchased or leased land if duly notified. A conditional leasehold may be transferred with the land in respect of which it is granted.

Crown lands, to the extent of 200,000 acres per annum, may be disposed of by auction at upset prices per acre of not less than as to town lands, £8; suburban, £2 10s.; other lands, £1 5s.

Crown lands can be occupied (in addition to the occupation by "conditional lease," which, from its mixed character, is provided for, as above mentioned) in either of the following ways:—

1. Pastoral leases.
2. Occupation licenses.
3. Homestead leases.
4. Annual leases for pastoral purposes.
5. Special leases.

All existing pastoral runs (except when too small for the purpose) are to be divided into two equal parts, one of which will be resumed, and the other granted as a pastoral lease preferential to the existing run-holder.

Pastoral leases may be granted as follow:— Term, in western division, fifteen years; in central division, ten years; in eastern division, five years. Rent will be subject to appraisement at not less than—in western division, 1d. per acre for first five years, increase ¼ for next five years, and increase of ½ for residue; in eastern division, 1½d. per acre for first five years, increase of ¼ for residue; in eastern division, 1d. per acre. Right of renewal for five years (subject to possible increase of rent) and of surrender at expiration of any five years. Pastoral leases may be transferred.

Occupation licenses may be obtained for resumed areas or vacant land. They are to be granted preferentially to a run-holder over the resumed area of his run. Subject to appraisement, the license is to be not less than £2 per section of 640 acres. They are to be granted for each year ending December 31, and the rates, when appraised, are to be published. Failing exercise of preferential right by run-holder, they will be disposed of by auction or tender. On lease or sale of the land comprised in occupation licenses, the same to be cancelled, *pro tanto*, the license fees paid in advance being refunded, and compensation made for improvemeuts.

In the western division, homestead leases may be granted within resumed areas or of vacant lands in areas not less than 5,760 acres, nor exceeding 10,240 acres. Terms—Fifteen years, with same right to extension or renewal as pastoral leases. Rent same as pastoral leases in western division. Fencing must be done within two years. The holder must reside upon the land for at least six months of the first five years of the term. No pastoral lessees to hold a homestead lease, or *vice versâ*, nor shall any person hold more than one homestead lease. Homestead leases may be transferred only when the residence condition has been fulfilled.

Leases may be granted by auction or tender in arrears not exceeding 1,920 acres. Term, current year ending on any December 31. Minimum rental, £2 per section of 640 acres. Renewal: they may be renewed subject to increased rent, if exacted. N.B.—Land so leased is, nevertheless, open to sale, or to special or conditional lease.

Special leases may be granted of scrub lands in arrears not less than 640 acres, nor exceeding 10,240 acres; term, 15 years. Rent not less than 2s. 6d. per section of 640 acres for first five years, 5s. the next, and £1 for last five years, subject to certain conditions for clearing the scrub. Special leases may be also granted for wharves, jetties, irrigation, tramways, and other special purposes.

It will, therefore, be seen that land can be easily obtained for either agricultural or pastoral purposes, in portions and blocks well adapted to their respective requirements; and as there is always a natural craving for the possession of land, the facility of obtaining it must have its effect in creating a community similar to that which England possessed at the time when the small farmer cultivated his own land, made his own improvements, and took a proper pride in raising a family able and willing to assist him in his labours, and proud in the respectable independence which enabled him to gain a livelihood without being indebted to anyone. Men of this class are those who made England great; and Australians, brought up in the political and social freedom of their institutions, will not fail to make a name equally illustrious with that of their fathers.

After the occupation and tillage of the surface of the soil, we naturally come to the wealth which lies hidden underneath; and no industry is more important than that of mining. It was the discovery of gold in 1851 that directed the attention of the entire world to Australia. Its discovery in California two years previous, enticed hundreds of men from Australia, and the *auri sacra fames* seemed in a fair way to depopulate the colony. In May, 1851, however, payable gold was discovered at Lewis Ponds Creek, in New South Wales. The exodus to San Francisco was stopped, a world-wide interest was centred in Australia, population flocked to its shores, and in one huge leap it attained a national importance.

Gold had been known to exist for a long time before it was known how to extract it from the wash dirt. It had been actually found by Count Strzelecki, and by the Rev. W. B. Clarke, both eminent geologists, and by many individuals not possessing any scientific knowledge, but who had at different times and places found small specimens. Nothing practical was done, however, until the period above mentioned, when a gentleman named Hargreaves brought from California the invention of the "cradle." This gentleman had, previous to 1849, been staying at a cattle station of Jamison's, in the district west of Bathurst, and had noticed the number of quartz reefs that cropped out in many parts of the country. Afterwards, upon the Californian gold discovery, he was, in common with many others, attracted by their reputed richness to try his fortune at the American gold mines. In the neighbourhood of the Sacramento River he was struck by the similarity of the geological features of the country to those he had left behind him in the neighbourhood of Bathurst. He returned to Australia with the full intention of "prospecting" the locality, and in travelling there he became acquainted with Messrs. William Tom and John Lyster. These gentlemen had found specks of gold both in the Summerhill and Lewis Ponds Creek, and offered to show Mr. Hargreaves where they had made the discovery. This latter gentleman then made the first "cradle," and showed Tom and Lyster how to use it. The streams mentioned were "prospected," and eventually payable gold found at a point near the junction of those two streams, and which place they called Ophir.

This discovery vastly increased the material progress of the colony. It brought about, first of all, that emigration from Great Britain of exactly the proper class of men to colonise the country — men physically strong and adventurous in disposition; men of high courage, caring little for hardships, who came to seek their fortunes. These men arrived in thousands, and "leavened the whole lump" of Australian population with their sound common-sense. They kept the too adventurous and criminal in check, and, as a rule, supported law and order. In the second place, a better market was at once found for fat stock, farm and garden produce. Large quantities of gold were exported to England, and from that period colonial prosperity was assured. Victoria had separated from New South Wales during this year (1851), and soon after the great gold fields of Ballarat, Forest Creek, and Bendigo were discovered, and proved far richer than the fields of New South Wales. Up to 1883, the whole Australian yield had amounted to about 258 millions sterling, of which New South Wales had produced about one-seventh, and Victoria considerably more than five-sevenths. The total yield for New South Wales for the year 1844 was 107,198 oz., of the value of £395,291.

Some of the workings in New South Wales have been fabulously rich. I was personally present at Holterman's Mine, at Hill End, Tamberoora, when a slab of gold ore was raised weighing 630 lbs., which contained over £2,000 worth of gold; and the Sydney Mint returns from 415 tons of stone gave 16,280 oz. of gold, of a value of £63,234 sterling. The Wentworth Mine, at Lucknow, near Orange, is also exceedingly rich, and often yields ore which produces at the rate of 2,000 oz. of gold and 300 oz. of silver to the ton. The gold-bearing rocks in this locality are covered with a layer of basalt, varying from twenty to several hundreds of feet in thickness. Extensive silver mines have lately been discoved at the Barrier Ranges in the Albert district, and also at Sunny Corner, near Bathurst, where extensive works are in progress. About 100,000 oz. were mined during the year 1884, and there appears every probability that New South Wales will shortly become one of the great silver-producing countries of the world. Mr. Wilkinson, the Government Geological Surveyor, has reported that he examined eighty-one lodes in the Barrier Ranges, some of which were very rich.

Copper is widely distributed, and mines have been worked (more or less) ever since 1855. Large quantities of the metal have been produced, and over £4,500,000 worth exported. Many of the lodes are very large, and yield a high per-centage of copper. The low price of copper is sadly retarding this branch of mining, but over £400,000 worth was exported in 1884.

Tin mining is very similar in its nature to that of alluvial gold working. The heavy particles of tin ore have been washed out of their matrix, as the rock decomposed, like large grains of shot, and remain at the bottom of the alluvial, from which they are washed by means of sluices. These deposits have in places been covered with basalt, exactly in the same manner as the deep leads of auriferous drift. At a place called Vegetable Creek, in the New England district, very rich deposits of tin ore have been found, and it was in this locality, in 1873, that the first "deep lead" of tin was discovered. It was traced from the surface to below the pipe clay, gradually making its way to deep ground, evidently an old river bed, and beneath the basalt. This led to the discovery of many other "deep leads," and, no doubt, hundreds more will be found, giving employment to a considerable population for many years to come, as there are vast tracts of tin-bearing country not yet prospected. No one can venture to estimate the wealth sealed up in the old river beds beneath the basalt; and, while stream tin can be obtained, the lodes will be neglected; but in time these will be worked profitably, in a similar manner to what has been done in other countries. The returns for 1884 show a value of £521,587; the total value of tin exported since the opening of the mines, in 1872, amounts to £6,519,177. The export of last year is the smallest since 1880, the depression being caused by the very low price of tin.

Antimony ores have been much neglected, the market for the metal being a limited one. The sulphide of antimony is found on the Macleay River and in the Armidale, Clarence, and Cudegong districts. During the last two or three years some of the lodes have been worked, and over £50,000 worth of ore exported.

Immense quantities of iron ore exist in New South Wales. In immediate connection with coal, magnetic iron ore, hematite, clay-band of the richest description, containing scarcely any sulphur are found. Blast furnaces have been erected at Lithgow and Mittagong; but, after a struggling existence, the Mittagong works have been closed, and the low price of British iron has operated most detrimentally to that at Lithgow. Nevertheless, so far as natural facilities for the development of the industry are concerned, nothing could possibly be better. Iron of the very best quality has been made, but the works cannot be carried on to produce iron to compete with the exceedingly low prices which have prevailed for the last two years. However, with all the materials necessary for the iron manufacture in large quantities and easy of access, the industry must, sooner or later, assume important dimensions.

There are also lead mines in both the western and northern and southern districts. Lead ores, chiefly galena, are found at Peel, Sunny Corner, and Wiseman's Creek in the western district; at Glen Innes, and other places in the northern; and Murrumburra, Gundaroo, Silverdale, and near Bombala in the southern district.

Cinnabar, zinc, bismuth, and manganese have been found; but as yet no mining for these metals have been carried out.

Diamonds were discovered in 1851, but they were not specially sought after until 1867, when considerable numbers were found by the alluvial gold miners in the Mudgee district. The richest finds have been at Bingera, where, in 1884, at Doctor's Creek, the Australian Mining Company obtained 1,193 diamonds, weighing 254 carats. The conditions under which the Bingera diamonds are obtained are much the same as those at Mudgee, where the gems are procured from the outliers of an old river drift, which had, in part, been protected from denudation by a capping of hard compact basalt. This drift is made up mostly of boulders and pebbles, jasper, agate, quartz, flinty slate, silicified wood, slate, sandstone, and an abundance of coarse sand mixed with more or less clay. Diamonds are also found in other parts of the colony. From the Borah tin mine, situated at the junction of Cope's Creek with the Gwydir, 200 were obtained in a few months. Out of a batch of eighty-six, averaging 1 carat 1 grain each, the largest weighed 5·5 grains. Diamonds have been found on most of the alluvial tin workings at Cope's, Newstead, Vegetable and Middle Creeks, also in the Stanifer, Ruby, and the Britannia tin mines, in the Tingha division, near Big River, Auburn Vale, and in the Berrima district. In colour, the diamonds vary from colourless and transparent to various shades of straw-yellow, brown, light-green and black. One of a rich dark-green was found in the form of a flattened hemitrope octohedron. The most common crystalline forms which have been met with are the octohedron, the hemitrope octohedron, the rhombic dodecahedron, the triakis and hexakis octohedron, but they are all usually more or less rounded. The flattened triangular hemitrope crystals are very common. One specimen of the deltoidal dodecahedron was met with. The lustre is usually brilliant or adamantine, but occasionally they have a dull appearance. This want of lustre is not due to any coating of foreign matter, or to the same cause as the dulness of less hard and water-worn crystals, but it is due to the surface being covered with innumerable edges or angles belonging to the structure of the crystal. These reflect the light irregularly at all angles, and give the stone its frosted appearance.

If diamonds are the purest and most beautiful and expensive form of carbon, common coal is certainly the most useful, the most important, and the most valuable, and in no part of the world is there any country which possesses this mineral in greater profusion than New South Wales. She has far and away the richest, most extensive, and most easily accessible seams of coal in the southern hemisphere. So extensive are they that in this colony alone, the coal measures have over six times the area of the coal measures of Great Britain, and the quality is so excellent, that it has the highest reputation everywhere and for all purposes. The approximate area of the carboniferous strata is estimated at 25,000 square miles, and thick coal seams crop out along the coast and mountain ranges from Pier Head, near Lake Macquarie, to Newcastle Harbour, a distance of eighteen miles, on the northern edge of the great coal basin. From Coal Cliff to near Shoalhaven, a distance of forty-five miles at the southern side of it, and on the western side at the Blue Mountains, Lithgow Valley, Wallerawang, &c., thick coal and cannel-coal seams crop out alongside the railway from the metropolis to the western interior, and in the gorges and gullies on the southern railway similar outcrops of coal occur.

The mines, first opened in 1802, are situated in the immediate vicinity of Newcastle, and it is there the colony obtains its largest supply, where the shipment of coal is carried on by hydraulic and steam cranes, and shoots, capable of loading 20,000 tons per day.

The production of coal has increased very rapidly of late years. In 1833 only 328 tons were raised, whilst in 1884 the total output was 2,749,109 tons, valued at £1,303,077. There were 64 coal and shale mines in operation, employing 5,500 hands. The year's exports reached 1,690,763 tons, valued at £931,045. When it is remembered that the coal-fields of Great Britain only cover one-twentieth part of the area of the country, or about 4,000 square miles, and that, nevertheless, the output of this mineral in the mother country is upwards of 120,000,000 tons per annum, it would be difficult to over-estimate the magnitude of the proportions to which the coal trade of New South Wales may be expected to grow hereafter.

The rise and progress of this trade have already been very remarkable. A small convict settlement on the "Coal River," as the "Hunter" was then called, has been transformed into the city of Newcastle, and the *débouchement* of this river has been made—by the construction of a breakwater connecting the detached rock called the "Nobby" with the mainland—into a commodious and safe harbour, attracting a larger quantity of shipping than Sydney itself. It is, perhaps, difficult to realise this great fact, but so it is. I have often heard persons say they remember the adits that were driven in the cliffs by convict labour, and when the coals were drawn from the shafts by hand, with a simple winch. At the present time Newcastle is provided with every modern appliance for the mining and shipment of coal, and many of the mines have each an out-put of over 1,000 tons daily. Hydraulic cranes catch hold of the waggons as they come down the various lines of railway, and, lifting them into the air, drop their contents—usually ten tons—at once into the hold of the ships that are waiting at the wharves for their loading, while other waggons arrive at the staiths, and tip their contents into shoots, which conduct the coals on board the vessels moored alongside to receive them.

The coal is of excellent quality for steam, household, smelting, and gas purposes, and the largest exports are to Victoria, Hong Kong, San Francisco, South Australia, Manila, Japan, Valparaiso, Honolulu, India, Tasmania, New Zealand, and Queensland, more than 1,000 vessels being annually engaged in this traffic.

The coal trade in the south or Illawara district differs somewhat from the trade at Newcastle. It is a very important industry, and in time must largely increase its present dimensions. The district possesses a large coal-field, and the coal is of a good quality, suitable for either steam or household purposes. Moreover, the coal can be raised and put on board ship at such a low cost, that the proprietors are able to sell with profit at a lower price than that at which coal can be worked at Newcastle. There are at present three places of shipment—Coal Cliff, Bulli, and Woollongong.

On account of the situation of the Woollongong and Bulli mines, which are worked high up the mountain sides by tunnelling, the coal is taken to the wharves by means of tramways constructed on the self-acting principle, by which the descending weight of the full waggons give the necessary power to haul up the empties; it not only does this, but provides the power to bring the coal out of the mine. These facilities make large economies in working a coal mine.

At Coal Cliff the workings are carried on in a different manner. The same seam of coal which is worked at Bulli and Woollongong crops out on the face of the cliff, some little height above high water mark. An adit has been driven on the bed of the coal, and a roadway made to a jetty, where, in fine weather, vessels can come alongside to receive the coal. This colliery is now in a condition to do a large trade, and will add considerably to the output of coal in the district.

The locality of the western coal fields is at Lithgow Valley, situated some 3,000 feet above the level of the sea, at the foot of the Zigzag which brings the Great Western Railway from the Blue Mountains into the valley below, which at that place is nothing more than a ravine scooped out of the rock by the action of water. In no part of the colony is there to be found greater evidence of progress than in the thriving town of Lithgow, where, as has been so well expressed by Mr. Charles Lyne, "the appearance of coal seams led to the opening of coal mines; rich deposits of iron ore brought about the speedy establishment of iron works; beds of clay, highly valuable for bricks and pottery, prompted the construction of brick and pottery works; the existence of copper mines, not many miles distant along the railway, suggested the erection of copper smelting works; good timber on the mountains pointed to the fitting up of steam saw mills; and the salubrity and coolness of the climate showed the late Mr. Thomas Mort the advantage of making the district a great meat emporium for the supply of the metropolis, and if necessary, for the markets of England."

The town has sprung into existence and developed itself during the last ten years. Some twelve years ago, when the Lithgow Valley Colliery Company commenced their operations, the country was almost wholly untouched bush land, with only some half-a-dozen families, while now the town takes rank among the leading inland towns of the colony for manufacturing works and general trade.

There are four mining companies, whose works are in active operation, viz.:—The Lithgow Valley, Eskbank, Vale of Clwydd, and Zigzag. These all work the same seam of coal, which is of a hard, semi-anthracite and semi-bituminous character, fairly well adapted to all household requirements, but especially suitable for steam and smelting purposes. Its average thickness is about 10 feet, and supplies most of the coal for locomotive purposes on the Great Western and Southern lines of railway. The output is very considerable, and constantly increasing. In this district the seams of coal are found immediately in connection with iron ores of excellent quality, limestone and fire-clay. In short, nature seems emphatically to have indicated Lithgow Valley as the great manufacturing district of the whole group of the Australian colonies.

The average price of the northern coal in 1884 was 9s. or 10s. per ton, of the southern 10s., and western 5s. 5·22d. per ton. In each instance this is the price at the pit.

The result of careful investigation is to prove that the coal from the northern coal-field of New South Wales is practically equal for all purposes to the best English coal; for the use of steamers it has the advantage of giving a more perfect combustion, with freedom from smoke. The coals of the southern coast and western districts differ from those of the northern coal-field in having generally a duller appearance, higher specific gravity, more ash, and less volatile hydro-carbons, in which they approach more closely the character of Welsh steam coal.

That petroleum occurs in rocks or deposits of nearly all geological ages, from the Lower Silurian to the present epoch, is the opinion of Dana; and Messrs. Cox and Ratte are of opinion that some oil-bearing rocks of great importance have been formed in a similar manner to coal, but under different conditions, and mention as instances the Scottish Boghead, or torbanite, and the very similar oil-bearing rock of New South Wales. This last-mentioned rock, known as "Kerosene Shale," occurs in lenticular beds of considerable extent in the coal measures, and probably only differs from coal itself by being composed of the remains of swamp plants, which have undergone decomposition under water, in some special conditions capable of preserving most of the gasses. If microscopical examination does not detect any organised structure as in coal, it is most likely because the water plants were of a much softer nature than those which formed the coal, and that the cells have been completely destroyed by fermentation. The New South Wales variety yields a much larger per-centage of volatile hydrocarbons than the Scotch Boghead, and occurs in saucer-shaped deposits from a few inches to five feet thick. The richest quality yields upwards of 150 gallons of crude oil per ton, or 18,000 cubic feet of gas, with an illuminating power of 38 to 49 sperm candles, and on this account it is found advantageous for mixing with ordinary coal in the manufacture of gas, and is largely exported to Great Britain, America, and other foreign countries, as well as the neighbouring colonies, for gas purposes. Two companies manufacture petroleum, shale oil, and other products therefrom. The quantity raised in 1884 was 31,619 tons, valued at £72,176. This industry was founded by Sir Saul Samuel, the present Agent-General of New South Wales.

We are informed by scientific men, that in less than one hundred years the coal supply of Great Britain will be exhausted. The Royal Commission appointed in 1871 fully confirmed this opinion, and came to the conclusion that there only remained at that period 90,207 million tons of coal in the mines already opened, and about 56,273 million tons in the unworked coal-fields, and that probably in 106 years the whole would be exhausted. I simply mention this in order to point out that the Greater Britain of Oceana has a supply that will probably last as long as the world itself.

The total quantities and value of minerals raised to December 31st, 1884, were as follows:—Gold, 9,596,653 oz., valued at £35,724,179; silver, 936,122 oz., valued at £223,697; coal, 31,261,326 tons, valued at £15,709,291; shale, 370,217 tons, valued at £828,198; tin, 71,109 tons of ingots and 15,618 tons of ore, valued together at £6,519,177; copper, 64,953 tons of ingots and 3,402 tons of regulus, valued together at £4,531,665; iron, 25,569 tons, valued at £206,060; antimony, 2,473 tons of ore and 142 tons of regulus, and 366 tons of metal, valued together at £57,921; bismuth, 33 tons, valued at £6,310; and 407 tons of mixed minerals, of a value of £12,286. The aggregate value, therefore, of the metals and minerals which have been produced in New South Wales amount to £64,068,584.

A much larger amount of gold has been coined at Sydney than has been raised in New South Wales, as during the twenty-seven years, ending with 1884, 14,108,558 oz. of gold has been coined, of a value amounting to £53,657,855 sterling; the product being 48,693,500 sovereigns, 2,280,500 half-sovereigns, the remainder being bullion, valued at £2,612,304. During the year 1884 there were coined 475,053 oz., of the value of £1,713,844, coined into 1,595,000 sovereigns, the remainder being bullion.

The population of new countries in the early period of their existence, are, more or less, engaged in a hard struggle with nature. The land must be cleared, the soil cultivated, and the wilderness made fertile; consequently, the chief portion of fabricated articles, requiring much hand-labour in their production, is imported; nevertheless the progress of New South Wales in manufacturing industries is very pronounced. The latest and most approved labour-saving appliances and steam-driven tools have been introduced, and the manufacturers are able to compete with those of Europe in the supply of many local requirements. Some of them have a steady export trade to other colonies, clearly showing that the articles produced are cheaper and better than those obtainable from any other source. The Registrar-General has returned the number of manufactories and works in existence, and the number of hands employed during the year which ended 31st March, 1884, to be as follows:—Connected with or dependent on agriculture, 204 establishments, employing 2,777 hands; working on raw material, the production of the pastoral interest, 307 establishments, employing 2,937 hands; manufacture of food and of articles of drink, &c., 307 establishments, employing 2,379 hands; building materials and plastic manufactories, 939 establishments, employing 6,659 hands; machine manufactories, brass, lead, and iron works, 215 establishments, employing 3,335 hands; miscellaneous works and manufactories, 1,139 establishments, employing 15,112 hands. At the close of the year 1883 there were in operation in New South Wales 154 mills for grinding and dressing grain, employing 2,847 horse-power, 390 pairs of stones, and 685 hands.

Sydney is the centre of the Australasian group of colonies. It is within a few hours of Newcastle, the great coaling station of Oceana. It is the great entrepôt of trade with all the South Sea Islands, and is in constant communication with all parts of the world. It is most admirably situated for all purposes of commerce. The harbour, for facility and safety of access, capacity, depth of water, shelter and convenience of shipping, leaves nothing to be desired, and is, moreover, one of the most beautiful in the whole world. In all these qualities it enjoys an undisputed Australasian pre-eminence, and possesses a world-wide reputation.

Well-built and extensive warehouses and bonded stores front the shores of Sydney Cove and Darling Harbour, which are divided by a long neck of land, giving an immense amount of water frontage. The city has already attained very considerable dimensions, and extends on both sides of the harbour—about six miles east and west, and four miles north and south. There are 121 miles of streets, and nearly 40,000 houses. Its population is about 300,000, or nearly a third of that of the whole colony.

More than one-half of the Australasian shipping is owned by New South Wales. The inward and outward tonnage of 5,361 vessels engaged in trade in 1883 was 4,006,237 tons, against 1,500,479 tons in 1871. Thus, we find in 1871, 1,891 vessels, equal to 706,019 tons, were entered inwards, and 2,133 outwards, equal to 794,460 tons; together, 4,024 vessels, of the aggregate tonnage of 1,500,479 tons. In 1881, there were entered inwards 2,254 vessels, equal to 1,456,239 tons, and outwards 2,203 vessels, equal to 1,330,261 tons; together, 4,357 of the aggregate tonnage of 2,786,500 tons. It will be observed that, while the number of vessels employed has not largely increased, the tonnage shows an increase of 1,286,021 tons, equal to 85 per cent. This is explained by the class of ships now employed to do the trade. Formerly they were the ordinary sailing vessels, but these have been superseded by large steamers, averaging 3,000 tons, making three trips yearly. The following statement shows the amount of shipping entered and cleared in each Australasian colony during the year 1883:—

Name of Colony.	Inwards.		Outwards.		Total.	
	Vessels.	Tons.	Vessels.	Tons.	Vessels.	Tons.
New South Wales	2,587	1,935,189	2,774	2,071,048	5,361	4,006,237
Queensland	936	455,985	867	426,506	1,803	882,491
South Australia	1,062	748,926	1,074	755,839	2,136	1,504,765
Victoria	2,023	1,464,752	2,064	1,499,579	4,087	2,964,331
Western Australia	219	194,273	212	194,829	431	389,102
Total	6,827	4,799,125	6,991	4,947,801	13,818	9,746,926
New Zealand..............	805	494,926	851	507,565	1,656	1,002,491
Tasmania	657	230,092	648	241,630	1,305	471,722
Grand Total	8,289	5,524,143	8,490	5,696,996	16,779	11,221,139

There is a Government dry dock at Cockatoo Island (Billoela), Port Jackson, in which H.M.S. *Galatea*, of 26 guns and 3,227 tons, was docked. Mort's dry dock is also capable of accommodating the largest class of mail steamers that come to the port. The Australian Steam Navigation Company has a slip capable of taking up a vessel of 1,503 tons, and there are also smaller private slips and floating docks. Another Government dock is being constructed at Cockatoo Island, which will take in the largest vessel now afloat.

One hundred and two vessels were built in New South Wales in the year 1883, consisting of 52 steamers, 12 schooners, 30 luggers, 3 cutters, 4 ketches, and 1 barquentine, showing an aggregate of 7,253 tons.

That the last ten years are worthy of being termed a decade of prosperity for the colony will be seen by noting the increases shown by the following figures:—

	Aggregate Import Trade.	Aggregate Export Trade.	Together.
	£	£	£
1852 to 1861......	57,650,053 ...	43,125,653 ...	100,775,706
1862 to 1871......	84,832,363 ...	74,148,876 ...	158,981,239
1875 to 1884.. ...	167,164,963 ...	152,283,164 ...	319,448,127

The trade of New South Wales expanded from £158,981,232 in 1862-71 to £262,679,613 in 1872-81, an increase of £103,000,000, or 65 per cent. on the latter period. During the last three-and-twenty years, the relative growth of imports and exports was as follows:—

	1862-71.	1872-81.	1882-3-4.
	£	£	£
Imports	84,832,363	133,070,409	65,068,872
Exports	74,148,876	129,609,204	54,864,485

The imports and exports per head averaged in 1883—

	1883.		
	£	s.	d.
Imports	24	18	8
Exports	23	13	2
	£48	11	10

Returns of the amounts of imports into New South Wales during the last three-and-twenty years give the following figures :—

	1862-71.	1871-81.	1882-3-4.
	£	£	£
Great Britain	32,575.549	60,983.506	33,203,045
Australian and other Colonies	37,926,669	60,244,755	25,306,642
Foreign Countries	14,330,145	11,842,148	6,559,185
	£84,832,363	£133,070,409	£65,068,872

The returns of the total value of exports from the colony during the last three-and-twenty years give the following figures :—

	1862-71.	1872-81.	1882-3-4.
	£	£	£
Great Britain	30,208,485	61,384 766	24,877,778
Australian and other Colonies	41,467,718	62,734,754	25,832,293
Foreign Countries	2,472,673	5.489,684	4,154 414
	£74,148,876	£129,609,204	£54,864,485

Although the trade between the Australasian Colonies and Great Britain is very large, that between the colonies themselves is even greater, and immense good has been effected by this commercial interchange.

The total value of the trade in 1884 amounted to—Imports, £22,827,585; exports, £18,251,506; or in all £41,079,091, with a balance in favour of imports of £4,576,079. As compared with 1883, the aggregate trade of the colony shows an increase of nearly a million. The imports from the United Kingdom amounted to £11,423,047, and the exports to £7,683,880. Trade with the other British possessions was—Imports, £9,185,876; and exports to £9,221,986. Imports from foreign States amounted to £2,218,662, and exports to £1,355,640.

The total Customs revenue in 1884 was £1,865,329, or £344,968 in excess of the figure for 1883. The Customs revenue for the year ending June 30th, 1885, was £1,717,265, of which £1,463,056 was collected in Sydney. During the first quarter of 1885, the imports at the Sydney Customs amounted to £4,700,893; and the exports to £2,998,660.

The following Table exhibits the increase of trade, compared with the census popultion, in decennial periods :—

	Population at Census.	Trade.	Per head.		
		£	£	s.	d.
1841	130,856	3.551,385	27	2	9
	After giving up Victoria.				
1851	187,243	3,360,843	17	18	11
	After giving up Queensland.				
1861	350,860	11,986,394	34	3	3
1871	503,981	20,854,540	41	7	7
1881	751,468	33,458,829	44	10	5

The public revenue has increased from £532,718 in 1851, to £7,499,878 for the year ended June 30th, 1885. Of the latter amount, £1,717,265 was obtained from Customs, £113,812 from Excise, £238,750 from stamps, and £121,338 from licenses. The land sales amounted to £1,267,510, and the total land reuenue to £2,007,813. The receipts from the national railways amounted to £2,357,934. The revenue from taxation is officially given at £2 4s. 10d. per head of the population for 1883. The revenue for the year ending June 30th, 1885, shows an increase of £918,646 on that of the previous year. This increase, it should be mentioned, is in face of the loss of revenue occasioned by the cessation of sales of Crown lands, in view of a change in the Colonial land laws. The tariff, which is established for purposes of revenue only, is one of the simplest in Australasia, free trade being the avowed policy of the colony. The revenue for 1885 is estimated at £8,485,250, towards which £3,714,957 was received during the first half of the financial year.

The public debt of the colony at the close of 1884 was £24,601,959 9s. 2d., the annual interest being £1,071,066 1s. 8d. Of the loans contracted by New South Wales up to the end of 1884, £22,606,717 have been for railways, which now return an interest of 4·37 per cent. annually on the whole capital invested. The remainder of the loans have been for public works principally of a reproductive character. These figures conclusively show that the object for which this money has been borrowed contributes a revenue equal to the whole interest on the debt, while the works themselves, which have been admirably constructed, are becoming every year more valuable. Strictly speaking, therefore, the colony is without debt, and consequently in a most enviable position as compared with all other British possessions.

The industrial stability of the colony is manifested by the operations of its banks, as during the past decade their progress far exceeded the increase in population, their circulation having nearly doubled, their deposits and advances more than doubled, and their coin and bullion reached nearly half as much again. At the end of June, 1884, the total paid-up capital of the various New South Wales banks was £8,960,000, and their reserves and undivided profits £4,771,005—equal to £13,731,005 of banking capital. This represents a diminution of £1,500,000 in the amount of the paid-up capital—the amount of that of the Oriental Bank—but the reserves show an increase of about £50,000. The total amount paid for the last dividends had been £635,250, ranging from 5 per cent. in the case of the London Chartered, to 25 per cent. in the case of the Commercial Bank of Sydney. At the close of 1884, the deposits in the New South Wales banks amounted to £26,259,419 sterling. Deposits in the savings banks have increased per head of population from £1 17s. 6d. to £3 12s., and the large amounts to the credit of the depositors, clearly show the existence of both prosperity and thrift amongst the working classes. The total number of depositors are 45,442, with a credit of £1,882,319.

Australian Earnings.—The earning power of the Australian community is greater than that of any other population in the world. According to Mr. G. Mulhall, F.S.S., the annual earnings per head in Australia are over £43, as against £35 in the United Kingdom, £27 in the United States, £26 in Canada and Holland, and £25 in France. The rate of wages is highest in New South Wales, where it exceeds £50 per head per annum. This causes the saving power to Australia to largely exceed that of other countries, the annual savings per head being—in Australia, £6 15s, while in the United Kingdom it is £4 4s. in the United States £3 17s., in France £3 13s., in Canada £3 3s., and in Holland £2 2s.

I may here mention that the wages obtained by artisans at the present time average from 10s. to 12s. per day of eight hours, agricultural labourers from £40 to £60 a year with board and lodging, while female domestic servants obtain from £26 to £50 a year, according to their capability.

It is impossible to overrate the importance of railways in their action of facilitating and developing trade. Without railways no country can hope to compete successfully in the great struggle for existence. Until the railways crossed the Blue mountains, the trade with the interior was on a very limited scale, nor could it be very much increased. Trade follows the rail, and the experience of Europe and America in this respect has been found to hold good in a greater degree in New South Wales, where there is such a pronounced absence of internal navigation. Their introduction has had the most beneficial results, which must continue to increase in direct proportion to their extension. They are entirely in the hands of the Government, excepting a short line from Deniliquin to Moama. It is much better that railways should be Government property, as money can be borrowed for their construction at a much cheaper rate than could be possibly be done by private companies. Moreover, when they are found to pay more than the interest upon the debt, the traffic rates can be reduced, thus benefiting the entire population of the colony without any loss being made on account of the reduction.

There are principally three great trunk lines, Western, Southern, and Northern. The Great Western line is now open to Bourke, a distance of 503 miles, with a branch from Wallerawang to Mudgee. The Great Southern. running to the Victorian border at Albury, on the Murray River, 386 miles from Sydney, which is there navigable for small steamers It there joins the Victorian system of railways which runs to Melbourne, thus establishing direct communication between the two capitals, a journey of 576 miles, run in about 19½ hours, or, including stoppages, at the rate of nearly thirty miles an hour. There is a branch line from Murrumburrah to Hay, which is 545 miles from Sydney. The Great Northern, which is not yet in communication with Sydney, but which starts from Newcastle and is open to Tenterfield, 380 miles from Newcastle, and near the Queensland border. There is also a branch running to Narrabri, distant from Newcastle 252 miles.

These railways touch nearly all the important towns and centres of population in the colony. The Great Western passes through vineyards and orangeries to Penrith and Emu Plains, where it begins the ascent of the Blue Mountain range, the summit level of which is reached at the Mount Clarence tunnel, at a height of 3,678 feet, and thence descends by the great Zigzag into the Lithgow Valley, where, as I have before stated, there are collieries, ironworks, potteries, and many other industrial works. In crossing the mountains the engineering works are necessarily very heavy and costly, but they have been well designed, and constructed in the most substantial manner, and the line carries, even at the present time, an enormous amount of traffic.

The passengers carried during the year 1884 were 11,253,109, and the goods traffic amounted to 3,124,425 tons. Included in this traffic were 2,168,990 head of live stock, 319,677 bales of wool, and 1,773,905 tons of coal.

The tramways are also under the railway department, and have now become a recognised institution in Sydney. They are worked by steam motors, and the convenience afforded by this means of conveyance is generally acknowledged.

More than 23,522 miles of common roads are open, affording intercommunication with every part of the interior, and about £5,000,000 have been spent in ten years upon their construction. Mail coaches run through every district. During the last quarter of a century more than fifty miles of public bridges have been constructed. About 3,000 miles of road are metalled, 1,600 miles are graded mountain passes, and the remainder for the most part drained and cleared, with bridges where required. There are also eighty-seven public ferries, four of which are worked by steam.

Wherever there is a township there is a post-office, and every village in the interior has its postal communication. The postage on letters within New South Wales is 2d. per ½ oz., excepting in the city and within a radius of ten miles thereof, for which the postage charge is 1d., while newspapers are carried free. The number of letters passing through the General Post-office in 1884 was 39,644,700, and 23,392,000 newspapers, facts which indicate much commercial activity and intelligence.

The total income of the Department for the year 1884 was £495,868. The total expenditure was £653,295. These figures embrace the Post-office, Telegraph Department, Money Order Office, and the Government Savings Bank.

The ocean mails are carried by the Peninsular and Oriental Steam Navigation Company, *viâ* Colombo and Melbourne; by the Pacific Mail Steamship Company, *viâ* San Francisco; by the Queensland Royal steamers, *viâ* Torres Straits; by the Orient Steam Navigation Company, *viâ* Brindisi, or *viâ* Naples; by the Netherlands-India Steam Navigation Company; and by the Messageries Maritimes (French lines), *viâ* Marseilles. Of these, the Peninsular and Oriental Steam Navigation Company, and the Orient Steam Navigation Company, despatch their steamers fortnightly, alternating so as to establish a weekly service.

Telegraph lines intersect the country in every direction, and a message of ten words, exclusive of the address, the latter being free, can be sent to any part of the colony for 1s. There were open in:—

	Stations.		Miles of Wire.		Messages.
1871	89	...	5,579	...	218,530
1881	318	...	14,278	...	1,607,205
1882	345	...	15,901	...	1,965,931
1883	368	...	17,272	...	2,107,288
1884	—	...	18,681	...	2,334,052

The total cost of construction was £601,459.

Telegrams from all parts of the world are published daily in the newspapers.

There are 416 money-order offices, and in 1873 the number of money orders issued in the colony was 92,744, representing a total value of £420,294 4s. In 1883 the number, which has steadily increased every year, was 275,592, representing a total amount of £963,697 10s. 9d.

I feel that my task has been very inadequately performed, as it is really impossible to do the subject justice in the limited proportion of a paper of this class. I have endeavoured, however, to place before you a compilation of statistical facts which will enable you to form an approximate idea of the position New South Wales has already acquired in her industries and commerce. You will be able to gather from what I have said upon the colony's early history how tedious and how difficult its advancement was during the first sixty years of its existence, and the rapidity with which it expanded afterwards, especially during the last decade, and how it continues to expand and double itself in what we may truly term an arithmetical progression. The Exhibition of the Colonies and India affords intelligible and striking evidence of this marvellous expansion—a development which has taken place under a system of government which gives free action to each of the self-governing colonies to carry out any line of policy, fiscal or otherwise, which their respective Parliaments may conclude to be the best adapted to their requirements. Until the time arrives when the Colonies shall be strong enough, in point of numbers, to take an important position in the direct Parliamentary representation of her people in the national councils of the Empire, I think this individual freedom of Colonial action far better, far simpler, and far more conducive to Imperial unity than any confederation of Colonies, which I am confident must have an opposite effect, and will ultimately lead to grave misunderstandings with the Imperial Government. It is to be hoped that this Exhibition will strengthen and further promote the interest and good feeling which at present exists between Great Britain and her Colonies.

Twenty years ago England would willingly have parted with the Colonies, considering them an incumbrance. Since that time, however, a change has come over the spirit of the dream of British statesmen. Public opinion warns them that it is dangerous to tamper with such ideas, or to entertain such sentiments, inasmuch as the people—the great democracy—are determined to uphold the union of Imperial interests. The ever-increasing importance of the Colonies has at last become apparent to the British nation, and the necessity for preserving inviolate their connexion with the British Crown becomes every day more striking and uumistakable. The population of Great Britain increases nearly half-a-million every year, and, like the bees, a swarm must leave the hive in which there is no longer any room for them. Surely it is better that the swarm should settle in our own territory than fly over the neighbour's fence, to become the subjects of a power which in the future may be that of an enemy.

There is no such thing as separation talked of in Australia, and any one who mooted it in a colonial community would be hissed and scoffed at. All the leading statesmen hold opinions entirely adverse to any such sentiment, and the people are all thoroughly loyal and passionately attached to their sovereign. Nowhere in her Majesty's dominions is the Queen's birthday kept with more enthusiasm or made a greater holiday, or is it possible that a sovereign could be more beloved, or spoken of with greater sentiments of devotion. The Australians are entirely a people of the people — there is no aristocracy, but the wealthy or upper classes are those who have been successful in business, and amassed either fortune or a competency; while the working classes are, as a rule, intelligent and thoroughly respectable. All alike are well-behaved and most subservient to authority. Generally fond of field sports and manly games, they are good shots, fearless riders, skilful oarsmen, and excellent cricketers. The out-door healthy life of the bulk of Australian young men fosters a love for these manly pastimes. In fact the national feeling is English, and the entire population as completely subjects of the Queen as the people of London. Liberty in the Colonies has not degenerated, but, on the contrary, there is as genuine a love of law and order as is to be found in the heart of Merrie England herself. Colonists, however, have to adapt themselves to circumstances and take such action as will accord with their needs; nevertheless, they are to all intents and purposes English of the English—in fact, some of your famous literary men, who have visited Australia, have said, "they are more English than the English themselves."

In comparatively a few years the British population abroad will be equal to that of the British Islands. This is an absolute certainty, provided the world continues its onward progression. The great self-governing Colonies are already complete communities in themselves, but naturally each has its own idiosyncracies, and their vested interests have less influence than in European countries. The early settlers took with them that love of freedom and impatience of tyranny which have always characterised the British race, and these have impressed their mark upon the colonial intellect, institutions, and laws. Colonials may be headstrong, but they are eminently filial; they are proud of their privilege as British subjects, and I quite agree with Mr. Froude that should the great misfortune of separation be ever brought about, I feel confident the fault will not be on the side of the Colonies.

The boundless territory of the great south land gives space for the increase of the British race, and scope for the devolopment of the strength and energy which our fathers achieved and have bequeathed to their children. Let us in imagination look over the heads of centuries into the distant future, and we shall see the colonies of Australia as they have expanded into a mighty nation. The beauty, the wealth, and the resources of that highly favoured land, have, in working out its destiny, produced generations of healthy and vigorous humanity, strong in the faith and traditions of their fathers. We see men sprung from sires who were not ashamed of toil, who thought work honourable, and believed that "labour is good for man, bracing up his energies to conquest." We see men who have made themselves illustrious by their love of country and noble deeds, their advocacy of the equality of human rights and love of freedom, and we see a nation who cherish and maintain those high and sacred principles which have been approved by God and man ever since the world was created. We see a great people, as the sands of the sea in multitude, with their wharves and quays crowded with produce, and their harbours full of great ships. We instinctively look for the bridge which connects this land with Great Britain; we cannot distinctly see, but we trust it may be there. The mirage which hangs about the horizon obscures the view, and so the future is hidden, and we cannot perceive whether the Australia of the future stands alone, or is still in connection with that grand old fatherland in which we all take such an honest and proper pride.

The most ardent wish of the great Napoleon was for ships, colonies, and commerce, for these, he argued, were absolutely necessary to make an Empire prosperous, powerful, and wealthy. Great Britain has become possessed of all these, of a power, magnitude, and profusion such as could never have been dreamt of by the illustrious ruler and general who aspired to establish an Empire in France equal to that of ancient Rome. Moreover, she is mistress of the ocean, and garrisons every *coin d'advantage* for guarding the approaches to her vast possessions. Can it be possible that she will, through inadvertence or carelessness, abandon these inestimable privileges and these illimitable territories, her people's patrimony? We answer No, ten thousand times no. Our fathers, in a hundred battles, won them for us against all comers, and made the maritime glory of Great Britain a "track of continuous light." Shall we become degenerate, and lose the superiority for which they so gallantly struggled and so nobly obtained? Rather let us cultivate that patriotic spirit which cannot be better described than in the stirring words of the old song, that—

> "We, their children, will maintain their old supremacy,
> And where'er a vessel spreads a sail, we'll rule the stormy sea."

DISCUSSION.

Mr. Hyde Clarke complimented Mr. Combes on the clearer position in which he had put the question of the New South Wales debt, which had been so much misunderstood. Mr. Combes showed that the debt of the colony was applied to railways almost exclusively. He (Mr. Clarke) would, therefore, point out, again, that the right mode of comparison is not with the figures called "public debt," but with those of "railway capital." Thus the New South Wales figures per head represent solely railways, while for England the number per head represents "public debt" met by taxation. To this has to be added an equal amount for proportion of railway capital. In comparison with the United States, the proportion of "public debt" is very small, while the figures for railways is proportionally very much larger. Consequently the real question to be discussed is not whether the "public debt" of New South Wales or other colonies is too large, but whether the "railway capital" is too large, or is capable of further extension and development.

Sir Saul Samuel said Mr. Combes had dealt with this subject in such an exhaustive and able manner that he had left little for anyone else to say. He could only remark that the progress which the colony had made was something marvellous, and not only in the case of New South Wales, but all the colonies. They were apt to look to Canada as being the greatest colony, but comparing it with New South Wales, it would be found that the trade was about the same, whilst the revenue of the latter was somewhat larger. If, however, the whole of the Australian Colonies were taken together, the trade was now about £120,000,000; if ever they became federated into a Dominion—as he hoped some day they would be, for he did not altogether agree with Mr. Combes on that point—the trade, if continuing at the present rate, would be nearly three times larger than that of Canada. He did not wish to detract from the great colony of Canada, but still one could only judge of the greatness of countries by comparison. To give an instance, showing the great progress made by the colony of New South Wales. In the year 1819, which was in the lifetime, perhaps, of some present, at any rate, it was just one year before he himself was born, he did not know whether there was a Board of Trade in England at that time, but, at any rate, there was a Government regulation that no vessel under 350 tons should go to New South Wales; the idea being that the voyage was too perilous for vessels under that tonnage. A meeting was held in the city of Sydney, in that year, at which Sir John Jamieson principal surgeon of the time, presided, with the object of petitioning the English Government to allow vessels of 150 tons to go, because it took so long to load a vessel of 350 tons that it delayed postal communications so much that people despaired of getting their letters within a reasonable time. Vessels now went to the colony every week of from 3,000 to 5,000 tons; there could not be a greater proof of progress. There was another point on which he did not agree with Mr. Combes. He did not believe there was any apathy on the part of the English people in regard to the Colonies. There was a time no doubt, some fourteen or fifteen years ago, when Professor Goldwin Smith, and others of the same school, advocated the separation of the Colonies from the mother country. These gentlemen considered the Colonies were likely to be a burden to the mother country, but they little dreamt of what was in prospect—the vast progress likely to be made, or that the time would come when, instead of there being a desire to cast the Colonies adrift, they would seek to bring them closer. That was really so at present. He would not say there was not a class of politicians at one time in the Colonies who thought they could do better separated from the mother country, but they were not very far-seeing, and it would be difficult to find such men now. The Colonies had nothing to gain by separating from the mother country, but everything to gain by remaining a part of the Empire, and, as Mr. Combes had stated, one never heard in the colony any talk of separation. They were more loyal even than the people of England, and took every opportunity of showing it. They were demonstrative in their loyalty to an extent which English people would hardly credit. The Queen's birthday was kept as a holiday because they loved the Queen and the old country; and they also took advantage of the Prince of Wales's birthday to do the same thing. This did not apply to Australia alone, for in Canada they observed the Queen's birthday in the same way, closing the banks and business establishments, and the familiar air of "God save the Queen" was to be heard in all directions. Long may she reign over the Empire.

Mr. BOLDERAT expressed his admiration for the able exposition which Mr. Combes had given of the progress of New South Wales.

Mr. P. L. SIMMONDS said he had had the pleasure of being associated with Mr. Combes at the Paris Exhibition of 1878. He had also charge of the Colonies in the Exhibition of 1862, and there was certainly no apathy then in regard to them; but, nevertheless, the desire for information in regard to the colonies had been advancing year by year. In 1867, at Paris, he had charge of the Australian Colonies, and he might say that the various products there shown attracted a good deal of attention from the French, who were not generally a colonising nation. They were much surprised at what had been done then, but if they now looked at the progress which had been made, they would see how much these colonies had developed their industrial resources, whether mining, agricultural, pastoral, or manufacturing. The Colonial Exhibition was certainly far beyond any expectations which could have been formed of the progress of the Colonies by those who took part in the first great Exhibition of 1851, Several of the industries had advanced marvellously. but he would allude especially to the wine industry. In 1867 he did his best to bring the various wine products of Australia before the French people, and they were awarded several silver medals, but since then the Australians had advanced very much in the processes of manufacture, and the report of Mr. Bonard had done a great deal to advance their wine trade. At the subsequent exhibitions, both at Antwerp and Amsterdam, the Australian colonies had come out very well, although they did not put forth their whole strength as they had now done. One other industry which had been greatly developed was the meat industry. Twenty or thirty years ago, before this Society, in dealing with the utilisation of waste substances, he took occasion to advert to the deplorable fact that so many sheep were boiled down simply for their tallow, when food was so much wanted in this country. Soon after, Mr. Harrison, of Geelong, advocated the frozen meat industry, and since then it had advanced to such a stage, that it had become an extensive trade, both in the form of tinned meat and frozen meat. Mr. Combes had not had time to refer specially to some features of the colony's progress, particularly educational and industrial, but those who examined his figures, when published, would see that the progress made had been very marvellous. He could remember the first gold discoveries, and read a paper on the subject before the British Association at Glasgow, about 1855. He little thought then that the amount of Australian-derived gold would advance to 316 millions. But their mineral wealth was not limited to gold; the coal industry all over the colonies was probably one of the most useful, and it was highly important that England should have coaling stations in all parts of the world to which British vessels went.

Mr. LIGGINS said he could not say too much in commendation of the valuable communication they had had from Mr. Combes, though he could not agree with him as to the undesirability of some kind of federation with the mother country.

Mr. COMBES said he referred to a federation between the colonies themselves; any other form of association he had always advocated.

Mr. LIGGINS said that colonists were often more loyal than they were at home. He was rejoiced to think that the Prince of Wales had brought before the public of England something to show them the great importance of the Colonies to this country The necessity of the Colonies for stay at home people was becoming more and more clear every day. There was in England a surplus population of great intelligence and educational capacity which could not do better than go to the British Colonies, rather than to an antagonistic country wherever it might be situated, whether a kingdom or a republic. The Colonies of England furnished a climate to suit every constitution, and they were all within about a month's voyage, for New Zealand now came within thirty-five days, and the cost of transit was very slight.

The CHAIRMAN said it only remained for him to propose a vote of thanks to Mr. Combes for his interesting paper. In spite of the alleged apathy of this country, colonial affairs did receive a great deal of attention, and the importance of the Colonies to the empire at large was, he thought, pretty generally recognised, as was proved by the emphatic and striking recognition of that importance which was shown only two days ago in the opening of the Colonial Exhibition by her Majesty the Queen. No one who was privileged to see that magnificent spectacle would ever forget the hearty and expressive manner in which the ceremony was performed by those persons who were principally concerned in it. No doubt New South Wales had taken its fair share in that Exhibition, though he had not yet had time to examine what it had done. Those collections would speak for themselves, but they were all indebted to Mr. Combes for the light he had thrown on the commerce and industry of the country, and for the way in which he had enabled them to appreciate the energy, intelligence, and public spirit of the inhabitants of this particuiar colony.

Mr. COMBES, in reply, said there appeared to be some little misunderstanding with reference to what he had said about the federation of the colonies. It was simply of forming the colonies themselves into a Dominion of which he spoke. He had unremittingly, during the last fifteen years, during which time he had taken some active part in colonial politics, advocated, as strongly as he knew how, some stronger kind of union with the mother country. He might be wrong, but he had recommended the same principle which had made an united Germany out of the fragments of which it consisted before it was taken in hand by the great man who now ruled its destinies. In that case the unification was consolidated by a Customs union, but he thought they had better go on in New South Wales as they were going until time and circumstances should point to what was required. It was well to leave sleeping dogs alone; they were going on very well. He believed a federation of the Australian Colonies to establish a Dominion would quickly lead to some misunderstanding with the Imperial Government. If there had been a Dominion in Australia during the time of the New Guinea fiasco, there would have been a very grave misunderstanding. New South Wales and Victoria were already sufficiently powerful to bring a large number of men into the field if they had to raise an army, and there was no doubt that the Colonies could take care of themselves if any attempt should be made to invade them. It was a million times better, however, to continue in the happy union with the mother country, and in every possible way to consolidate the Empire. He thought, especially with reference to New South Wales, that they would lose prestige if there were to be a Dominion, and no longer have the absolute power to manage their own affairs. It was not as if they had a constitution like the United States. They had not a number of States and a Congress with a President wielding a power of veto. It was only when trade had declined with other nations, when it was found that the United States, Germany, and France, by their progress in manufactures, and by their protective tariffs, were almost able to supply themselves, that the English people—of the Manchester school—began to see that it was absolutely necessary to keep the Colonies, or they would have no customers at all. There could be no doubt that was the feeling at the present time. He was commissioned, under the Great Seal of the Colony, to make an inquiry with reference to technical education in other countries, and in doing so had found that other countries were making such rapid strides in manufacturing industries that they would leave very little for England to do in the way of making goods for them. It would not be long before the English people would see the necessity of forming such ties with their Colonies as to increase and solidify their own trade, and to guard their own against all comers. At the present time he thought it best to let things go on as they were. He was aware of the great interest which the late Mr. Forster and Lord Roseberry took in the colonies, but those who did take such an interest, even at the present time, were few and far between. He could only hope that this Exhibition would create that interest in the subject which was due to its importance, which was due from a mother to a child, and which could not fail to produce good results in the future. He had not said anything about education, as it was outside the scope of his paper; but being intimately connected with technical instruction in the colony, he might say that it had already made great strides in New South Wales, and was quite up to the average of that given in England. The plan adopted was based somewhat on that of South Kensington. They had not introduced trade or industrial schools, but they taught the sciences that underlaid the various handicrafts. With reference to primary education, the system was secular, compulsory, very nearly free, and a child could get as good a rudimentary education as anywhere in the world. Moreover there had been established within the last three years schools for secondary and higher education, so that already there was a complete system which would aspire to what Professor Huxley said he wished to see in England —viz., that education should resemble a ladder, of which one foot was placed in the gutter, and the top of which reached the university. With regard to technical education, there were seventy classes in Sydney alone, and many of the distinguished professors of the University gave instruction. He wanted to give all the information he could about the Colonies, and if he could only interest a few, they would speak of what they knew to others, and thus information would spread rapidly. Whilst talking about the mother country and the Colonies, the establishment of Dominions, and the future seat of Government, he would ask them to suppose for one moment that the tie which existed between the United States and Great Britain had never been broken—Great Britain with her thirty-five millions of population and America with her sixty millions — where would the seat of Government be now? It was only fair to mention this so as to induce thinking people to consider what the probabilities are for the future. These Colonies would have a population in 100 years much greater than that of the United States, because the countries of Europe were more densely populated, and the stream of population must go somewhere. It must go to Australia when the United States were full. Therefore the dependencies, if they continued dependencies, would become much more populous than the mother country. It only required to look forward and these matters would be arranged. The thing would have to be looked at from a broader point of view. If the mother country and its dependencies come together in one government and one great bond of union, there must be a Congress, or a House of Representatives, in which they will have an equal voice with the voice of Great Britain.

INDIAN SECTION.

Friday, May 7, 1886; SIR JULAND DANVERS, K.C.S.I., in the chair.

The paper read was—

INDIAN MANUFACTURES FROM A PRACTICAL POINT OF VIEW.

BY B. H. BADEN POWELL, C.I.E.

It is difficult to deal methodically with such a subject as that on which I have been invited to address you, because there is no one point from which a beginning can be made, or any single conclusion towards which we can make our way. I feel, then, that an apology will readily be accepted for the somewhat desultory nature of my remarks. I can only hope to invite your attention to a few of the more interesting peculiarities of, or circumstances which are notable in connection with, Indian manufactures.

My remarks, I should explain, necessarily refer chiefly to that part of India with which I am familiar—the Panjab and Northern India; but I do not desire to be precluded from an occasional reference to other parts; and much of what is said will, I think, be found to be true generally.

The term "practical point of view" introduced into the title, means that I do not intend to call your attention merely to the beauties of Indian manufactures, but rather to some of the characteristics of Indian labour, its place and opportunities in the commercial life of the people.

Much indeed might be said, and attractively said, from the purely æsthetic point of view. But there is less occasion for a paper on this subject, because everyone is now able to see specimens of Indian art manufactures in the Indian Exhibition, not to speak of Mr. Purdon Clarke's acquisitions at South Kensington, while the editors of illustrated magazines have long found out what attractive letterpress may be put together regarding Oriental work, and what charming scope for the bright lights, delicate tracery, and deep shadows of wood-cutting, Indian art objects afford. Moreover, there is a special journal devoted to the subject. As this periodical is not as well known as it deserves to be, I am glad of the opportunity to recommend it. The illustrations, chiefly due to the cultivated taste and careful supervision of my friend Mr. Lockwood Kipling, Principal of the Mayo School of Industrial Art at Lahore, leave nothing to be desired. The work only costs 2s. a number, and is to be had at Mr. Bernard Quaritch's. Some ten numbers have already appeared. It is admirably printed by Mr. W. Griggs, of Hanover-street, Peckham, S.E.

The first thing that strikes the student of Indian life is that Indian manufactures are strictly such; they are all handicrafts. It is true that at Calcutta there is a considerable and increasing out-turn of "jute" fabrics, made in great mills by steam-power;* and in Bombay a still larger manufacture of cotton-twist, yarn, and plain cloth is mentioned.†

In one or two places paper-mills (*i.e.*, machine mills) have been established, and you will perhaps allow me to digress for a moment, to remark that this form of manufacture constitutes one of the most hopeful enterprises of the future if only one or two obstacles can be overcome. The chief of these is the supply of bleaching agents. They are absolutely indispensable, but those in use are costly, owing to the objection of shipowners to carry them, and for what reason I do not know, the local production of the requisite chemicals has not yet been successfully undertaken.

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* Jute is the fibre (something like hemp) of *Corchorus olitorius* and *C. capsularis*, two very similar herbaceous plants, of the same order as our lime or linden tree (*Tiliaceæ*). The jute manufacture gives employment to close on 43,000 hands; and the value of the exports amounts to nearly £2,500,000, of which £1,500,000 represents "gunny" bags and cloth, chiefly sent to the United States and to Australia.

† The foreign export (chiefly to Aden, Zanzibar, Mozambique and Arabia) has risen from a value (in round numbers) of £1,085,000 in 1878 to £2,180,000 in 1882. And if the inland and coast export of Bombay is added, a total export of close on £5,000,000 is reached.

The native style of writing does not demand the same sort of paper as English correspondence does, for the writing is done with a comparatively soft, pointed reed, and the ink (of lampblack and gum) does not penetrate the paper. The best native paper is made in Kashmir, and this is in demand for all formal and complimentary letter-writing among the higher classes. But Kashmir paper is merely a thinner and finer class of the same paper as is usually made. The latter is unbleached, is thick, and coarse or open in texture, and it cannot be written on till the surface has been polished by the application of a surface layer of wheat size, burnished with an agate rubber (or piece of smooth horn), or a curved board. Such paper is bulky and heavy, and, even now, for letter-writing, foreign thin notepaper is in demand, for Kashmir paper is costly; and though foreign paper is dearer than the common native make, the cost is compensated by the saving in postage. No doubt the use of machine paper would become general (as it now is for all English official records, and all native documents of a permanent character) if it could be produced locally, and was not rendered rather dear by foreign freight and carriage charges. Paper fibres abound in India, like young bamboo-shoots, flax refuse, jute, hemp, cotton, and many wild plants and barks.* Much attention has been given of late to the collection and partial preparation of paper-stuff for export, especially when the periodical alarms about the supply of esparto grass recur. But it is obvious that such export is, as far as India is concerned, a waste of money and labour, since the stuff exported has to be brought all the way back again in the form of paper.

But to return. Setting aside the steam-mills, all the native manufactures of India are handicrafts. And to this is, in great measure, due the characteristic beauty and individual interest of the work. There is something human about it, which there is not about unvarying machine-cut scrolls of wood or metal ornament, and the regular yard to yard pattern of our prints.

These crafts, then, can always hold a place of their own, provided their character and quality is maintained. There is a distinct place for them in the market, which cannot be taken away so long as labour is so cheap in India. We talk here of 1s. a day as very low wages; in India it is a coveted remuneration for even skilled labour, at least in most parts.

The origin of all native Indian craft skill is pre-historic; and go back as far as we may, all we can discern in the way of first origins is the occasional introduction of a ready-born craft from foreign countries, *i.e.*, from Persia and the north-west frontier; the introduction being due to the conquering hordes which came from the north-west and settled in India. Once established, the arts remained what they always were, both as regards means and materials, designs and objects. But one result of this fact of indigenious crafts supplemented here and there by foreign introductions, is that we have a number of crafts, Hindu in their origin and with decorative patterns and forms of their own; and another set, such (for instance) as the decoration of pottery and encaustic tiles, the gold damascening of steel, and the inlaying of marble, which are Persian or Arabian in their origin, and consequently Mahommedan. A broad distinction of Hindu art and Mahommedan art is everywhere discernible in India. The Sikhs of the Panjab may perhaps represent a third class. They took kindly to various crafts, but specially to carpentering and wood carving, and to metal work. They also founded a distinct architectural school, and have shown a great disposition to keep the same sort of design in the wood and metal work; their school is essentially eclectic—a combination of both Hindu and Mahommedan forms and ideas.

It is not intended to be asserted that the Hindu and Mahommedan styles have remained always and absolutely apart. Independently of the Sikh work, the collocation of races and the effect of time, would surely tend to fuse the two styles to some extent, together. All I mean to say is that we can trace certain forms and designs to a Mahommedan origin and others to a Hindu.

The character of the handicrafts is naturally preserved by the (fortunate) Oriental slowness to change, and a sort of non-inventiveness and lack of desire for novelty, which marks most Indian races. It is strange, then, that with this undoubted advantage, there should be any danger of the old ways being deserted. But still, as a fact, there is such. Side by side with the natural conservative tendency another influence is seen at work, and both must be borne in mind. On the one hand, ideas and methods are slow to change; the workmen rarely change their old tools except to the extent of getting (for example) English chisels, saws, or planes, which do not alter the style of work. The forms of ornament and pattern are all traditional, are often described in technical terms and symbols (in some cases amounting to a kind of trade language), and are handed down from father to son. At Delhi, there is a memorial mission church, with a doorway of beautifully sculptured stone. The carver of this assured me that he was descended from, and had inherited the ideas of, the craftsmen who, in the 13th and 14th centuries, decorated the matchless "Kutab minár" of Delhi; the great minaret intended to be one of four, which is familiar to most of the audience from photographs. But, while on the one hand, this "close-guild" system of work and the preservation of traditional methods and patterns tends to keep up the individuality and national character of work, on the other hand, the workmen evince a quite simultaneous tendency to adopt what they fondly suppose to be "modern improvements." A skilful carpenter, for example, who desires to extend his business beyond the making of the limited class of purely native articles, will turn his attention to furniture; but he soon gives up his old ornaments altogether, and hastens to produce copies of European woodwork, doing this as well as he can from perspective and rough cuts in a Tottenham-court-road catalogue; and he proudly shows you the result, as "asl Wiláyat"—the real European article. At Simla there has long been a large colony of carpenters and cabinet-makers who have there every facility for their trade. Walnut is the common wood; a finely veined wood of the rosewood class (*Dalbergia*), and a pretty yellow mulberry can be easily had, besides the deodar cedar, and the "tûn" or so-called "bastard mahogany." There being a large European community, the demand for furniture is considerable, and for some years past every house almost, has been supplied with copies of bad originals, in the shape of folding-chairs, side-tables, what-nots, and corner *étagères*. All are exactly alike, except that the work and carving gets worse and worse. Fortunately the exhibition at Lahore in 1882, and the efforts of persons of taste, who have furnished better designs, have now wrought a considerable reform.

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* The paper-stuff of the future, I venture to think, will be the splendid bark of *Broussonetia papyrifera*, a small tree, indigenous, I believe, in Burma, and easily culturable (with the important requirement of plenty of water, however) in most parts of India. I had it flourishing in the public gardens at Lahore.

The desire to introduce foreign forms is very natural; and arises partly from the idea of pleasing the European customer, and partly from an idea that to copy anything English is a sign of "progress" and intelligence. An amusing illustration of this may be given. In Lucknow a pleasing form of metal work (silver incrusted on blackened zinc or pewter) is common. I had asked a workman to make me a specimen, leaving it to him to choose his own form and ornament, hoping, of course, to get an original native design. What was my surprise, when, after the duly long delay, I received an exact copy in metal, of an English quart beer-bottle, the rim at the cork, the bulge of the neck, and the hollow at the bottom, all faithfully reproduced; but the whole covered with an Oriental design of raised silver work!

Another modern invention, trivial as it may seem, has become a positive nuisance in India. I allude to the cheap and crude aniline dyes.* Yard upon yard of what would otherwise have been good embroidery is now disfigured by dazzling green, awful purple, and blueish-crimsons of the "Judson" type — colours which never harmonize, and always produce a peculiarly vulgar glaring effect. No attempt to combine or soften the tones has been made, though I suppose such a process is possible. In India the silk, &c., is always dyed with the simple or brightest tint.

It is of course quite out of the question to object to the adaptation of Indian work to modern requirements; indeed, it is one of the first necessities of the day, if the crafts are to be made remunerative on anything like a large scale. Not only does the export trade demand it, but the tendency of education and material progress in India is to enlarge the requirements of households and of objects of personal use.

One of the reasons why forms in solid in India are so few, in comparison with the wealth and variety of flat design and pattern for surface decoration, is the extreme simplicity of household furniture and household vessels. In an ordinary Indian home everyone sits on the ground, a low stool or a cane settee being here and there found. There is practically no furniture for the different rooms. The bedstead is a simple frame, supported by four short legs, often lacquered or carved and decorated; there may be a few boxes for clothes and valuables; more rarely a low octagonal table (called "takht-posh"); and some low stools with upright backs (called "píri"). Cupboards are made by recesses in the brickwork of the walls. In country houses baskets or clay receptacles for grain are to be found; and this is all that is wanted. The fashion of sitting on chairs has become a matter of form for persons of superior rank; indeed, rank is often distinguishable by the question whether the man is a "Kursi-nishín" (entitled to a chair) or not. But the chairs in use are all very ugly copies of an English conventional type, with curved back-board and arms.

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* The imports of dyes (chiefly of the aniline class) increasd from £140,000 worth in 1873 to £207,000 in 1882.

Household vessels, whether of metal or earthenware, are few, and of stereotyped forms, each with its own name. The only later addition, I believe, has been the universal adoption of a metal drinking cup with straight sides, shaped like our tumblers, and called by the adopted name—significant of origin—"glás" or "gilás." If we add to these the brass lamps, often picturesque enough, and a few objects of personal use, we have nearly exhausted the list of Indian forms.

A number of the indigenous forms will no doubt always remain in demand for use at home, and perhaps still more, curiosities or ornaments for export. But if the trade is to develop at home and abroad, it must keep pace with the times, and adapt itself to new forms, without losing its character and its ancient excellency. It is quite possible for it to do this: and here is one of the main duties of our Indian Schools of Art, namely, to show how to adapt traditional forms of ornament and work generally, to the requirements of modern furniture and architecture, and to objects of use and ornament outside the stereotyped requirements of old Indian life. Excellent examples (to take a single instance) of this application of Oriental style to modern furniture may be found in No. 4 of the *Indian Art Journal* already alluded to.

This subject has attracted the attention of the Government of India; resulting in the issue of an excellent resolution (March 29, 1883). The plan of the Government it may be well to explain briefly. It consists in establishing at the museums of the Presidency and provincial capitals, which I may call show or sample-rooms, in which typical specimens of each class of work, got together from local centres of handicraft, may be preserved. Visitors, and commercial agents, can thus see what the country produces, and order duplicates or similar work applied as they may require.

In order to keep the provincial museums supplied, there are to be local museums chiefly concerned with the preservation of the products of the special locality. Managing committees are to watch over these, encourage and develop the local trades, and send specimens bearing fixed numbers to headquarters. The fixed number is the guide to prevent error and disappointment in executing orders, and it will save detailed and possibly misleading description. It thus depends on local committees to find out all that is worth encouraging, and to suggest developments and new applications of trade work, and to furnish designs, and prevent as far as they can, the use of bad models and false colours. In this work they will often have the aid of the art school director, or some other person who takes a special interest in Indian crafts. It is quite surprising how much there is to learn in any place regarding its manufactures. An official, if he has no particular taste that way, may live for years in a place without knowing its handicrafts. And it must be borne in mind the Indian workmen are very ignorant, and quite innocent of any idea of advertising their wares or pushing them in the market; so that they need help, and also being directed to good developments of their art, and restrained from copying bad models, turning out hasty and inferior work, and making such "European" imitations as I have attempted to illustrate. It is not always easy to do this. For the native gentry, on whom we must rely in many cases to work the committees, are not always in sympathy with the plan of adhering to good old work. It is unfortunate that the richer among them, themselves consider it a mark of progress to get imported articles for their households; and though they have unequalled facilities for making their houses perfect models of taste, and instances, which it would be worth travelling far to see, of beautiful Oriental decoration, they prefer only too often, to spend their money on showy European goods, buying up gaudy incongruous pictures, French *ormolu* clocks, and Brussels carpets that are frightful. But to get native gentlemen with leisure on to committees, and give them a real interest in helping on their fellow countrymen, is, in itself, an object of no mean importance. And I have always found among my many native friends, men eminently open to reason and willing to be guided in the right direction. When once they see the truth of the argument and the advantages of the plan, they will help in a way which, owing to their knowledge of native life, no foreigner can equal.

The mention of local committees and local museums naturally leads me to remark that all handicrafts are excessively local, sometimes confined in an unaccountable way to a single village, or a few families in a single town. Not only so, but where the class of work and the material employed are the same (as of course they often are) in different localities, each developes and adheres to its own style of form and ornament.

For example, the making of brass vessels is one of the commonest trades. Such vessels are often decorated, sometimes with beaten ornaments — generally beaten in from outside (the interior being filled with a slightly yielding matrix of clay, wax, and lac, so that the raised portions of the work are forced up by the pressure of the bed as it is beaten all round). At other times a chiselled, engraved, or punched ornament is preferred. It is nearly always possible, to anyone acquainted with Indian brass-work, to tell where any particular specimen has come from. Thus the Benares brass-work is quite unlike any other. The chiselled bowls of Pinddádankhán, in the Panjab, are distinctive, and the incrusted brass and copper-work of Tanjore is unique. Brass vessels are mostly used by Hindus. The Mahommedans commonly prefer copper-tinned, and this gives rise to a beautiful assortment of chiselled copper-work, in which case the surface is tinned over and the pattern lines often filled with a black composition, producing a kind of *niello*.

The trays, native tea-vases, and other forms in this work from Kashmir are well known.*

In a similar style Peshawur has a specialty in the "aftiba and chilamchi," a graceful long-necked ewer and basin, used for washing hands after a meal. I mention this in connection with the Kashmir work, because the material is the same, and the origin of both works is equally Persian, though now the character is quite distinct.

Another markedly local metal work is the *niello* of Murádábád (North-Western Provinces). Here the brass, partly silvered or whitened with quicksilver, is decorated with a tracery of black lines and leaves, or the surface is black and the lines only left white. The art of blackening zinc and inlaying or incrusting it with silver—a work of the class known as "bidar" or "bidrí"—is practised at several places, in Bengal (I believe) at Patna, at Lucknow in Oudh, and at Haidarábád in the Dekhan; but each locality has its own characteristics.

In woodwork, the Mainpúri (North-West Provinces) inlay of brass wire on dark wood—a marvel of delicate and patient skill—is unique, and quite unlike the brass inlay on wood of Hushyárpur in the Panjab. So with the delicate inlay in geometrial patterns of Bombay. Of late years only (as far as I know), a single workman in the Amballa district of the Panjab has undertaken similar work. The work is probably familiar, in the form of card-cases, desks, and boxes, to many of my audience. It is done by taking tiny three-cornered rods of coloured wood, ivory, and soft tin, grouping them in a pattern and fixing them together with a cement, the preparation of which is a trade secret. Thin slices are cut off, and these are fixed on to the surface of the box, or other object to be inlaid. The interstices are filled up with similar sections of other groups, or with pieces of ivory; and the bordering is done with lines or bars of ivory, ebony, &c.

I might fill pages with details of other works, all strictly local, but I must confine myself to a few. The fabrics of wool and cotton and silk, made in hand-looms, are such. Peshawur silk, Lahore and Amritsar silk, Baháwalpur silk, Bengal silks, Bombay (Thána) silks, Madras silk "sárís," are all distinct and characteristic. So with the gold inlay or damascening of the Panjab and other places. So with a work of very limited application, the lacquered toys and vases. In the Panjab the articles are turned in wood which is coloured by the application of mineral colours, or crimson lac, in resinous sticks. These are pressed against the wood kept rapidly rotating, and the deposit is burnished down with a bamboo edge and a bit of cloth with oil.* The colour is either uniform, or by touching on several colours successively and rubbing them together, a marbled or mottled surface, very pleasing to the eye, is produced. But bands (and sometimes whole surfaces) of incised ornaments are introduced, and the process is so curious, that you will pardon my stopping for a moment to describe it. Suppose a band carrying a running line of leaf and flower pattern is desired. The workman first covers the band with scarlet; over that he lays a layer of green, and then, over all, a layer of burnished black. He now lightly draws the "bel," or running pattern, with a point. Next he takes an angular-pointed chisel (called in the Panjáb "rach"), and for the stalk will cut through all the colour layers, thus exposing a curved white line (the wood is white or yellowish, often of *Capparis aphylla.*) Then for the leaves, he will lightly remove the black so as to expose the green layer, for the flowers he will cut down to the scarlet; lastly, he puts in some sharp touches, again exposing the white wood, between, for the calyx. Thus a flower pattern in white, green, and red, on a black ground, is produced. No mistake is ever made, though the slightest error in depth of cut would expose the wrong layer of colour; if a mistake were made I do not think it could be rectified. I have seen whole vases covered with a delicate tracing of this kind. I could at once tell by the style, whether the article came from Dera Ismail Khán or from Firozpur, or from Lahore or Hushyárpur.

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* The same form and style of decoration are also often produced in silver, or in silver enamelled, or in copper gilt and enamelled.

* The rotation is effected by fixing the article on two spikes or spits, supported by uprights firmly fixed in the ground; round one end of one of the irons the thong of a bow is twisted, and, by swinging this to and fro, a circular motion is produced. This plan of producing rotation is also adopted generally by carpenters in boring holes. And it is noteworthy that the gimblet—so much handier to use—has not displaced the old bow and turning awls, even in shops in which English chisels and gouges may be found.

Indian pottery again, though of course made at many places, is, if decorated, quite characteristic. This is the more remarkable, because, in most places, kaolin is unknown,* and the surface of the red clay has first to be whitened by a wash under the glaze, and as the turquoise or copper blue, and the dark blue of zaffre or cobalt ore (lájward), are the colours most generally available, it would be natural to expect a great similarity; but it is not so. Multan blue and white is unlike Delhi ware in the same colours, and unlike that of Bombay, though the latter, being mostly made at the art school, is eclectic in style and various. Both are different from the Sindh pottery, which, however, deals more in rich red, yellow, and green, than solely in blue and white. Of unglazed pottery, the little town of Rohtak, in South-East Panjab, has a form and style of pale brown clay, finished with a lustre of finely powdered talc, quite unlike anything else. The Bahwalpur State (South Panjab), besides its ugly distemper and painted ware (which of course is not durable), makes thin "paper" pottery also of talc-finished brown clay, but quite unlike that of Rohtak.

Wood-carving cannot be passed over, though time warns me to be brief. It is one of the most likely trades—if it is not *the* trade *par excellence*—for encouragement by exporters of Indian wares. The carpenters of the Panjab are sometimes Sikh, sometimes Mahommedan; but this fact does not produce much difference in style, for although the beautiful geometric "Pinjra," or tracery work, is distinctly Mahommedan (witness the similar lines in the Alhambra) the Sikh carpenters have assimilated the Mahommedan ornament to a great extent. In the Panjab, wood-carving is mostly of an architectural character, at least in origin; being applied to doors, to door-frames, to lattice-windows and shutters (when glass was unknown), or to balconies and projecting window-shades. The public will have a good opportunity of studying this work in the decorated hall put up in the Exhibition by workmen brought from Bhera, a town in the Sháhpur district of the Panjab. It is entirely different from the wood-carving of Delhi; and that again from several styles of work in the North-West Provinces, and from the splendid work of Ahmadabad (Bombay Presidency} and Southern India. As if these varieties were not enough, we have in Burma, where wood-carving revels (so to speak), all the better class of buildings are of teak wood and ornamented—an entirely new departure. The Burmese carving, which is now extensively applied to furniture as it is in Bombay and Madras, is totally and markedly distinct in style. It is not Chinese, and yet forms a link which can be felt but not explained in words, between the Hindu work and the absolute Mongolian.

I will only mention one other class of work in which the local character is so discernable; this deserves mention because it is another kind of work, which might have a considerable trade-prospect before it, I allude to cotton-prints. They can be made in any length or width. I had a large room at Lahore tapestried to half-height with a beautiful design made at Kapûrthálá, which cost me for the four walls about £4. Dados, curtains, *portières*, screens, and other draperies, either flat or to hang in folds, can be made of this work. The purchaser can order his own quality of cloth, either "markín" (European or Bombay mill-made cotton) or the looser and coarser "dosúti" of the native looms, which, however, is woven in rather narrow widths. The printing is done with a number of rather small blocks carved in high relief out of dark, hard "shísham" wood (*Dal-*

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* The Delhi pottery clay is a rough kind of kaolin, and white or whitish naturally.

bergia) or other similar hard wood which will not fray out in using. The designs of the combined blocks are various. Often architectural forms are used (especially for "dado" pieces) and the arches are filled with conventional flowers and foliage. Or a delicate, uniform pattern is stamped in pale red on a cream-coloured ground, and a bright border added. Lovely greens, and blues, and yellows, either bright or of the "old gold" type, deep reds and vivid crimson (not, however, permanent, this latter) are the colours chiefly used. Not only flowers and foliage, but also animal figures, and men on horseback are introduced. (This kind of ornament is called "Shikárgáh.") I could not enumerate all the places at which such work is produced. Lahore, Multan, Gugaira (Montgomery district), Kapúrthálá, are only a few names that occur to me at once; but no matter what the place, the print is sure to have some distinguishing characteristic and style about it.

The ordinary native use for such fabrics is to cover beds or floors (jhájam), or to line tents and awnings; but they can be applied to a variety of purposes.

Their merit lies in their colour, design, and character; but the work is often rough, and the manufacturers require to be induced to bestow care. For they themselves do not in the least care if the pattern is awry, if a block here and there fails to give a complete impression, or if different shades of what should be the same colour, are used side by side. No thought also is taken as to how a border is to go round the corner at right angles. Nor does one piece always join on to the next correctly.

It is obvious that only a little care is needed to obviate such defects. This, it should be added, is an instance of an Indian craft that can only hold its own as long as it is done in the old way, with the old colours and by hand. It is dependent, therefore, on cheap labour. While the necessary conditions exist, no European competition is practically possible, for no machine-printed cloths would have at all the same effect.

Having so far noticed some excellences of Indian handicraftsmen, it is necessary to advert to some obstacles in the way of trade development. One is the inveterate dilatoriness of the workmen, and their dislike to settling down steadily to work. Or if this overcome, by a large demand, they go to the other extreme and work with feverish eagerness, thus producing hasty and poor work, and probably overstocking the market. People on the one hand get tired with waiting, and with sending again and again for work that is never ready, or get disgusted with bad and ill-finished specimens, and so the craft falls into neglect.

A very intelligent collector of Indian wares once jokingly remarked, that the only way to get real work done would be to catch all the best craftsmen and put them in a jail! Handicrafts of course must take time. But it is not that; it is the habit of sitting down for days and days together before the work is touched even. All goods have to be ordered and materials arranged for *ab initio*. Except in the case of embroidered goods and carpets (and a few other articles—rarely the best of their kind—now kept in stock by middlemen in the large towns visited by travellers), no stock of made-up goods or shop full of specimens is to be found. Consequently, an order has to be given, materials provided for, and a price settled; but more frequently the workman will not fix a price—only take something in advance. He prefers to let the purchaser see the effect of his work before settling the price. In many cases it is a matter of search to discover the workman. Then the difficulties follow: the workman cannot stir himself up to make a beginning.

In one of the numbers of the *Indian Art Journal*, I have given my experience of attempting to start in business, and advertise the work, of a clever engraver of brass I found in the bazaar, wasting his time on petty work that brought him a wretched pittance. That he could have work which for him would have brought a small fortune, there can be no doubt, from the results of the one or two pieces of work I induced him to turn out. And I have from time to time taken other artisans in hand, and tried to bring them forward. Having got a specimen or two of their work, it was only needed to show these to visitors to procure requests for further work, which a little trouble would have multiplied. And if piece by piece were finished regularly, according to a time promised, with due respect to what is really needed for the patient and necessarily slow handwork, all would go well, and a continuous and paying employment would result. In time the labour would be divided, one man taking the rough material, and the best workmen only doing the fine work or the finishing. But no! The rule is never do to-day what you can put off till to-morrow. Message after message had to be sent for the long over-due work, and always the same excuse: the man's grand-mother was dead; his son was ill; and so on through the whole chapter of fictitious accidents. People then give up the hope, and buy something else that is procurable; and thus the local market is missed.

On the other hand, if the idea of making a profit does get into the mind of the craftsmen, they will take more orders than they can execute, or make more pieces than they can sell. Then some others will compete with them in price, without any regard to real calculation of successful price competition; and the result is, in a short time, that such bad, rough work is offered, that buyers will not accept it; the craftsmen get discouraged, and the trade is threatened with extinction.

Haste and roughness can never be allowed to become emphasized in native work, for roughness and ill-fitting of parts is already marked enough even in work good of its kind. The beautiful inlay of ivory on dark wood—a specialty of the Hushyárpur district (two or three villages only, I believe)—was a conspicuous instance of this. I possess some picture-frames and a cabinet made in the best days, and the work is out of all comparison with that produced later, when the style became known and fashionable. I believe, however, that this work will revive, if it has not already done so, under local care.

The universal Oriental habit of fixing no rationally calculated and ascertained price for goods, but of asking an exorbitant figure in expectation of bargaining, has its bad effects on some crafts (embroidery, for example), because it leads to absurd prices being offered. The people, therefore, give up good and laborious work, and offer something for which the lower rate will be a profitable price. Anyone who will examine the *double* stock* a Delhi embroidery-seller can often be induced to produce, will realise this effect for himself. But this is a matter which will be cured by time and by practice, as goods come more into regular demand. The people really do not at present know what their work is worth, and have not the least idea of calculating and allowing for this and that. They have had no experience to guide them. In the old days, an inlayer of arms, for example, brought a fine shield or a bit of armour to some courtier. The thing took the great man's fancy, but a regular price was not thought of. Perhaps he did not pay for it at all; perhaps, in a good humour, he tossed a bag of two or three hundred rupees, but it was "largesse" and not a trade-price at all. That was quite the common way of dealing. Regular price comes from steady business-like trade.

I feel that with these details I have already trespassed too long on your attention, I will, therefore, only remark further, that the maintenance of the handicrafts of India is not merely a question for curio-collectors and the pleasure of the few. It is really a very important matter for the welfare of the country.

In the Panjab, it is true (and the same may be said of other parts), the population is essentially agricultural; that is, nearly five-sixths of the whole derive their living more or less from the land. But still the number, relatively small but positively large, of castes and families whose hereditary occupation is trade and manufacture, must not be overlooked, especially not with regard to the rate at which population increases; for it is obvious that the area of profitably culturable land is limited, and a time must come when the limit is reached. But trade in manufactures of all kinds that are local, and not obtainable elsewhere, is capable of quite indefinite development. Not only might the export demand be increased, but the home consumption. For as education advances, so surely does the desire for a better style of living; and that means more complicated arrangements in the household, and wider requirements in the way of furniture, utensils, and objects of personal use. All this might be taken up locally to the great benefit of the manufacturing classes.

And as the cost of living increases, as it must do, so will the inducement become greater to break through old caste ties and turn to manufactures. At present every one that is not a born craftsman tries to get either a bit of land or a Government post—"naukari," as the phrase is. But land is limited, and the number of Government posts, even including the humblest, is still more limited. And if a man has land, still, as his family increases, it will be a great thing if he can supplement his income from handicraft labour.

Nearly all women in the Panjab (for instance) can embroider in silk or cotton. As usual, the styles of the different races and localities are traditional and well marked. Chiefly the work is done for "chádars," or wrappers and veils for their own use; but the demand for these embroidered pieces has already developed largely, and a regular profit might be made in many agricultural households, as it now is in a few. It is not in all castes, that the women engage in field labour; the majority have much time on their hands, which they at present fritter away in gossip, and in cotton spinning, which is much less profitable.

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* One of cheap rate for the inveterate, but ignorant bargainers, another for those who care for good work and are willing to pay a fair price.

Caste is a great hindrance to the multiplication of crafts. All trades go by caste, and caste sub-divisions, or are at any rate hereditary in families. I have often been surprised to notice in the Panjab how almost exclusively the making of Oriental carpets is confined to the larger jails, and so rarely conducted outside them. This is chiefly because carpet-making castes do not exist in the Panjab (except in the Déraját to some extent) and those who live in jails are of various castes and tribes. The jail authorities introduced this work because it is a suitable one, profitable to the Government, liked as a reward for good conduct, and because long-termed prisoners have time to become thoroughly proficient. I once asked a man at the central jail of Lahore, who had acquired great skill, whether on his release he would not set up a loom of his own (as his term was about to expire). He at once replied, "No, he was a 'Kasai,'" that is, of the butcher caste, and would return to his hereditary occupation.

Yet the carpet trade ought to be most profitable. The loom, made of a few poles and ropes, costs little or nothing to set up; and all the capital needed is a supply of coloured wools, cotton-thread for the web, and a very few tools.

This feature of caste has no necessary connection with any religious feeling, or with any other feeling that the friend of the people need fear to touch, in persuading them to take to trade. Nature also helps by refusing to be so bound, and often developing gifts of skill and aptitude outside the hereditary line. Already in every bazaar, and in almost every town, some workmen may be found, who have joined as apprentices without previous family connection with the trade.

Let me only add, in conclusion, a few remarks about middlemen. One of the problems in the encouragement of Indian manufactures is how to get the work known and introduced into the market. The people themselves do not know how to push their goods, or get them sold and obtain further orders. Nor, as I said, are they reasonably firm in the matter of price. It has already come to pass in some places that middlemen buy up and keep show-rooms of embroidery, and of the Delhi work in gold.* It is probably so to some extent with Bombay inlay, ivoryware, and other goods. But there is great fear of the system spreading unheeded; for no supervision of the middlemen is possible, and no native of the class can be trusted with unchecked power over his inferiors. He becomes a petty tyrant at once. The result would be that the workmen would be wretchedly paid (as they are, I know, in the case of the Delhi gold work), and the profits all go to the middlemen. In England, we have already heard much against the middleman system; and if it is abused—to the detriment of both purchaser and craftsmen—here, how much more so will it be with the ignorant and often simple hand labourers of India.

This subject is well worth the attention of those who take a social interest in Indian manufactures.

With this I will conclude. I trust you will not have found the subject, poorly as I have treated it, wholly devoid of interest; and I shall be amply rewarded if I have awakened any sense that there is a practical side to the question of Indian handicrafts, with which persons devoted to social problems can occupy themselves, and which imply something more than a mere effusive interest in a nice bit of brasswork here, or an embroidered veil there. We need more than an interest which expends itself in momentary desire to possess the object; we desire one that will go on to give some thought as to the labour, the work, the cost, who has made it, and what place the trade may have in the social policy of the great Indian Empire.

DISCUSSION.

Mr. T. H. THORNTON, C.S.I., said this paper was a most interesting one, especially to himself, as he had been connected with the Panjab for about 25 years, and took a great interest in all that concerned the people and the development of its manufactures. He was especially interested in it from having been a fellow-worker with Mr. Baden Powell, and knowing how eminent and trustworthy an authority he was in all the matters with which he had dealt. He was distinguished in many capacities—as a judicial officer for his accuracy and aptitude, as a botanist in the management and development of forests, and also as the writer of two most valuable works on the products and manufacture of the Panjab. He hoped the paper would prove valuable in giving a practical stimulus to the development of Indian manufactures.

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* A local work known as "gokrú," or by Europeans as "babul work," because of its resemblance to the flower of the *Acacia arabica*. Little spheres and hemispheres of gold are covered all over with minute gold spikelets, which are fixed on point by point with cement, and then the whole fused together with gold solder.

Mr. BRYCE said he had had occasion during his residence in India to appreciate the importance of a great number of the difficulties to which Mr. Baden Powell had referred in the latter part of the paper—the difficulty of securing continuity of work, of dealing with the question of middlemen, and the difficulty of getting at the workmen at all in the case of a great number of manufactures. Travelling over India in almost every part, one found that every little village had some special manufacture of its own, but no one knew anything about it, or who were to be trusted to do good work. The Government officers were sometimes very kind in endeavouring to do what they could in this way, but their efforts often failed, and they could not, under present circumstances, be expected to act in the capacity of middlemen. He had often tried in Burmah, where excellent work both in wood carving and silver was done, to get orders executed for friends, but had always found the greatest possible difficulty in getting the workmen, however good, to keep always up to the same standard. He wished Mr. Baden Powell, with his experience, had been able to suggest some feasible solution of the middleman difficulty. He had pointed out very forcibly the danger of the work getting into the hands of native middlemen, but he did not know, from experience in England, that it would be much more satisfactory if it got into the hands of the class of people who were tradesmen in England. If to begin with, at all events, some Government department could arrange to receive orders, and take the initiatory steps for getting industry started on a comprehensive scale, it would be a good thing. It was very unfortunate that the Government of India, having made a grant of a considerable sum of money towards the Exhibition, did not complete the outline which had been sketched, by allotting a further sum to enable persons in charge of the various exhibits to come along with them; but, as usual, the India Council wished to economise, and did not see its way to incur this additional outlay.

Captain TEMPLE said he might mention an amusing instance of the fondness of the native workmen for European models, and of the queer ideas they entertained as to what would please English taste. Some years ago he had a native servant who took a holiday, and went to see his parents in the Panjab; while there, he bought, by his direction, a pair of surajis or goblets, made of marble lacquered ware, and as a whole they were very good pieces of workmanship, but all round them he had placed, as a compliment to the owner, in large white letters, "Captain R. C. Temple, Esq.", which, of course, rendered them useless. Mr. Powell had referred to the difficulty of bringing forward native workmen; and he had tried to do the same thing; and in addition to the difficulties already referred to, he might mention one which was inseparable from the native character, viz., the idea which every man had who found a patron, that that patron should be his all in all—must feed him, find him in work, and, in fact, make a gentleman of him. Mr. Baden Powell had mentioned a man named Suraja, and he was one of the first to bring him forward at all. Some of the work he did was remarkably good; and he tried to bring him from a small to a much larger place, where he might make more money. He, therefore, brought him to the larger place, with all his family, but the result was that when he got there he expected him not only to find him employment and to get him good pay, but also to give him about 20 rupees a month, which to a native of that class would be affluence. After a time he had to send him back, but he was glad to find he had now distinguished himself by making some very good things for the Exhibition. Another case of the same kind was that of a man who lived in Umballa, a maker of pottery images. He took him up to Simla, where he thought he could improve his position, but there he found he was expected not only to find him in work, but to see that he got a proper price. He charged rather high, and the consequence was he did not get many orders, and in the end he came and sat down at his door day after day in the way natives would when they had a grievance, and worried him until he sent him home. In trying to improve native workmanship, there was one difficulty which had not been mentioned and that was the tendency to over-decorate, especially engraved or inlaid work. In the forthcoming *Indian Art Journal*, there would be a paper on the Panjab lacquer ware, which he had been asked to edit, which would contain a couple of illustrations, showing a wooden box from Bushipoor, inlaid with brass as the native had made it, viz., with much more brass on the surface than wood. Accompanying this would be another illustration, showing the same box with the superfluous ornament painted out, so that the great improvement which could often be effected in native work, by removing superflous ornament, was apparent. There was one kind of local work in the Panjab, the carved silver ware; this was made by cutting away strips of silver about 1-8th or 1-16th of an inch thick, and carving it with fretwork saws. The effect of the work as performed in Umballa was very good, and worthy of further improvement. After these strips of silver were carved, they were bent round into bracelets, necklets, and things of that sort. He was glad to see that Mr. Baden Powell noticed the advantages of using Indian work for English furniture. This was especially applicable to lacquer ware. He had a bedstead made some years ago of black lacquer ware traced on red, with fittings of bright steel, which looked very well indeed, and he should like to see the same kind of ware brought into general use. There was another kind of Indian native ware very useful for hangings, well known by the name of pulkari, or flower-work; it consisted of ornamenting the coarse cotton cloth with floss silk, and the effect was always good. He had tried it in English drawing-rooms, and wherever it was used it always tended to brighten up the rooms, and it might become a regular industry. Reference had been made to the paper pottery, and he had seen some which was almost as fine as paper, and to those who liked very delicate ware, he could highly recommend it as an ornament for drawing-rooms. It is generally painted, but not enamelled in any way. With regard to the depreciation of quality caused by Indian workmen imitating European, there was a striking instance in the Mysore carpets. In a small town, a society was formed locally some years ago for promoting the growth of carpet manufactories. At first the materials were dyed by the natives themselves, the colours were fast and bright, and the workmanship very good; but of late aniline dyes had been introduced, and the workmen were getting careless; the carpets were also more expensive than they used to be.

Mr. **Rogers**, having lived in the Bombay Presidency for a long time, was able to add a few words as to the difficulty of any improvement in native art. He thought Mr. Baden Powell would agree with him that it was in consequence of the hereditary nature of all these occupations. Each man pursued the same particular trade that his father, his grandfather, and all his ancestors had. Another reason why things had not improved was, the great want of intercommunication between different parts of India. Until railways were established no one knew what his neighbours were doing. A man might do excellent work in his own village, but the man in the next village to him knew nothing of it. There were no markets to which people had access, where their wares could become known; and if it had not been for the opening out of India by railroads, things would never have improved. People were beginning to travel about now, and see what their neighbours could do, and of course that would go on increasing. Some credit was due to the Government for the efforts it was making in the same direction, and he hoped Mr. Baden Powell would be able to confirm him in saying that, in the schools of art established in the different Presidency towns some effort was being made to teach handicrafts of different kinds to all who chose to come and learn them. In Bombay particularly, Mr. Kipling and Mr. Perry had done a great deal in that way. Many benevolent Parsees and others had established schools of art in different parts of the Bombay Presidency. He hoped this paper would be the means of opening the eyes of the people to what they could do towards developing trade in India, and especially that the natives who came over to this Exhibition would be induced to spend some of their money in establishing such schools, instead of frittering it away in buying articles de Paris.

Surgeon-Major **Pringle** said this was a most interesting paper, and everyone who had known India, and seen its manufactures amongst the natives, would see something in it to which his memory went back. He remembered the beautiful silver work at Kattak, and was distressed to see what a poor appearance it made in this Exhibition, and still more so on account of the reason, viz., the terrible famine which prevailed after he left, and which he feared must have swept off the workmen—men whose hands were capable of executing the finest work. They would take a palm, a rose, or any other natural object, and work it into a pattern most beautifully. In 1862, the magnificent collection of silver work, made under his superintendence, came to the Exhibition in this country, and took the highest prize in the world; and the Kattak work now exhibited was nothing compared to it. One of the great features of it, which was common to all gold or silver Indian work, was its exquisite lightness. Valuable Kattak work could only be purchased by weight; the lighter it was the more valuable it became. He had a large centre-piece, which he hoped he should be able to exhibit, and which till lately was in the Edinburgh Museum, where he left it many years ago when he returned to India; the stem was about fourteen inches high with a large bowl; the centre stem was a palm, and the bowl was a beautifully worked melon. He recollected designing the centrepieces; there was a melon lying on the ground, and he told the workman to copy that with all its tracery (which he did most beautifully), and to take the palm-tree in the garden for the stem. The native workman was always grateful for being helped, and quickly took in an idea when patiently explained to him, but he was generally poor, and required pecuniary advance, which was a great pity, though you could get over that by helping him. On another occasion, he got a necklace made of beautiful Bokhara onyxes, and he wanted to brighten them up a little with silver. The man asked him what he should put there. He threw a stick up into an oak tree, and knocking down an acorn, took the cup, and told the man to set the beads in such a cup as that. The native took it home and worked out the most beautiful design, and the whole thing was ridiculously cheap. He made one exquisite little casting, and then with a fine hammer drove the silver into it. But if you wanted good work, you must pay for it. Good work required a long time, and that required the man to be fed during that time. There was one great bar to silver work coming to England, which he had suffered from more than once in the case of presents, and that was the regulation of the Goldsmiths'-hall and the duty Talk of free trade, it was hard to take the food out of the country in thousands of tons, and tax the silver articles which they could make, and which would beat anything which could be done in England at the price. He hoped one outcome of the Exhibition would be an inquiry into this subject, for he was perfectly satisfied in these times of silver depreciation, if silver and other manufactures could be sent home under more favourable circumstances, it would be some equipose to the great loss on exchange in silver, which so many suffered from. There was no allusion to the rhea fibre, and he was sorry to say that did not seem likely to be a success in India. He had watched it with the greatest interest at Saharanpar, and if it could only be brought to perfection, what exquisite paper could be made of it. It grew luxuriantly, and where not touched by frost, yielded a fine crop of stocks; but unfortunately there was not a machine to work it into a fibre which would pay.

Mr. BADEN POWELL said Mr. Fourier had elaborate machinery for this purpose at the Exhibition.

Surgeon-Major PRINGLE said the Government, some time ago, offered a prize of £5,000 for a machine which would work the fibre up to a certain degree of fineness which would make it marketable.

Mr. BADEN POWELL said it was offered for five years, but no one claimed it; the first year there was a great fight over it, but the second year no one came forward.

Surgeon-Major PRINGLE said every careful observer must have noticed that the pattern of the mosaic in the taj of Agra went through a great many designs, and he had no doubt that a careful observer, like Mr. Baden Powell, must have seen in the taj the Italian work from which all the rest was copied; you could see the detail of the old Florentine Mosaic as plainly as possible. The same thing might be seen in the patterns on cloth, which had a most effective appearance, and when hanging up against the wall looked as if the whole side of the wall was inlaid with red cornelian and other precious stones. The Mohammedan work did not contain figures, which was in strict accordance with the second commandment, to avoid any representation of human or animal forms, and, therefore, they adopted scrolls in preference. Over the gateway entrance of the taj was the representation of a rope, exactly the same as might be seen in Melrose Abbey. The beautiful green enamel work of Kattak had been lost entirely, owing to a great outbreak of cholera, in which father and son died, and with them went the secret of the manufacture. This showed the necessity of trying to secure such valuable knowledge from being lost, through that which was an ordinary occurrence in those countries. He trusted the native workmen would never take to aniline dyes, which were so evanescent in an Indian sun, whilst the native dyes were remarkably permanent. It was very sad to see how nearly everything was coming into the shape of the *gilâs;* instead of the beautiful bowls which used to be made in brass-work, there was nothing now but the tumbler; and he could quite believe that anecdote which had been told about the beer-bottle. Another thing to be remarked with all Indian work was the prominence given to the beautiful form of the lotus flower which ran through everything, and in the same way in Cashmere you found the cone of the cedar tree, which design originally came from Egypt. The chief portion of the border work of the celebrated Cashmere shawls consisted of the cedar cone, or portions of it that had fallen off, but the point was turned round. He did not know why it was, and, on making inquiries on one occasion, he was told they did not like a straight line, and, therefore, gave it a curve! He had been struck with the remark about the woodwork, for, having travelled up and down the North-West Provinces for 20 years, he had seen a great deal of the woodwork there. The secret of this beautiful woodwork was that a man's character and credit were attached to the beautiful lintel that is over the entrance to his house, on which would often be found the most exquisite carving. It was a selected piece of wood, very old, where you would find the gunputty, the titulary god of the house, who supported it and kept it from danger, and little stories are put on the side. That wood-work had never been done proper justice to. In conclusion, he hoped some one would come forward, and do for the other courts of this wonderful Exhibition what Mr. Baden Powell had done so well for the Indian Court.

Mr. LIGGINS said he had never had the pleasure of being in India, but he should like to make a remark or two from an English point of view, especially with reference to what had been said by the last speaker. He congratulated Mr. Baden Powell on having given a paper which would enable everyone who read it to enjoy much more than he otherwise could the glories of the magnificent Exhibition at Kensington. He was surprised the first day he went there to see some of the wood-carving and marble-carving, and it would be impossible for anything to excel the work in the room which was now being fitted up for the Prince of Wales. He thought it would be a great misfortune if, in the technical art schools to be established in India, South Kensington had too much influence. He did not think a suitable ornamentation for anything in silver would be obtained by copying the 'prentice's pillar in Melrose Abbey. It was very charming where it was, but he hoped those who would carry on the work would prefer designs made by the Indians themselves, so that we might have Indian work, not what we had too often, copies of things made at Birmingham. He must protest strongly against the remarks of the last speaker with regard to the Hall-mark. Mr. Watherston was the only silversmith in England who had taken an active part towards getting Hall-marking abolished or modified, and he had used some harsh words about the treatment of light and exquisitely beautiful silver goods when they went to Goldsmiths'-hall. But was there any hardship, where the work was so light and beautiful, in charging a duty of 1s. 6d. an ounce? They cut a small piece out for the purpose of verifying the quality of the silver, but they always endeavoured to do so without injuring the article. It was illegal to import anything under a name which it did not deserve; if it was silver, it paid the duty, but if that which was sent as silver was found to be dross, it was very properly rejected. The buyer had a right to a guarantee of the quality, and he hoped the 1s. 6d. duty would never be taken off; for one of the prides of the old families of England was the family tea-pot and tea-spoons. They had all paid the 1s. 6d. duty, from the nobleman to the cottager, and they would have their silver depreciated to the extent of 1s. 6d. per ounce without any advantage whatever, except to a few tradesmen and purchasers of silver goods. Very few now bought silver spoons, because electro-plate looked equally good or better. He hoped the protecting power which had been exercised for 300 years by the Goldsmiths' Company, would restrain the public of England from having any interest in the importation of silver without duty. It was no hardship to India, because, whether the silver came from Mexico, Paris, or anywhere else, it all paid the duty, and it made the silver goods worth 1s. 6d. an ounce more. A dessert-spoon only weighed about three ounces, and the duty on that was not very much.

Mr. BRYCE said it was 30 per cent. of the value.

Mr. LIGGINS asked why should all his silver be depreciated 30 per cent.? It was very interesting to know what magnificent work was now done in India, but he was sorry to find that aniline dyes were being introduced. He wished Mr. Powell had given a little more information about the silver and gold work, which was of vital importance, and had been the subject of discussion for some years past.

Surgeon-Major PRINGLE said there were quantities of beautiful silver and gold things brought from India which never paid duty, owing to their being worn, as, for instance, his watch-chain; but the silver article he referred to was a present given to him by natives with his name upon it, and was not for sale, and on that ground he asked for exemption, but it was not granted.

Mr. BRYCE remarked that on application to the Custom-house they would not insist on the Hall-mark being put on very delicate articles, such as bracelets, when it was shown that the Hall-mark would spoil the work, but the duty had to be paid.

Mr. BADEN POWELL said such articles were not marked now if application were made, but the duty had to be paid. Only a few years ago, however, they used to break the whole thing to pieces. That was the great hardship that, if a man who did not understand the English standard, made an article which did not quite come up to the standard, the whole thing was smashed up when it came here. They were much more liberal now, showing that the agitation which had taken place had been of some use. It was a curious thing that the faith of the Mohammedans was not quite sufficient to keep them altogether from making figures. The Emperor Akbhar, who was something of a freethinker, had a deal of work of this kind done, and outside the fort of Lahore there were painted tiles full of figures, angels, and all kinds of things; so that the Mohammedans were not very strict. Some Mohammedans in Persia, who were Shias, and were therefore the most particular, drew the figures, but left an oval for the face without eyes or mouth. The theory of the Mohammedan faith was, that if you made a figure, at the day of judgment God would ask you to find a soul for it, and you would be confounded by not being able to do so; and they thought that, by leaving out the face, they would have made something which was not a human figure. He had purposely omitted going into metal work on this occasion, because, really, Indian silver work and jewellery, and the numerous styles of ornament, would form a subject for a paper by itself; and he had some idea of writing one for the *Indian Art Journal* on that topic.

The CHAIRMAN, in proposing a vote of thanks to Mr. Baden Powell for his interesting paper, said it was most desirable for any country that it should not depend for its subsistence on the mere produce of the soil, but that the intelligence and ingenuity of its inhabitants should be applied to convert that produce into such forms and shapes as would add to the comfort, and furnish materials for the use of the world at large. By that means the skill and industry of the country was made much more profitable, and a healthy trade was often introduced. In India, as they had learnt, industry and skill were present, but something was wanting to develop them, and that was capital. Industry supported by capital, directed by good taste, and worked in a businesslike way, would no doubt create a trade which would add very much to the wealth and improvement of the country. One difficulty which had been noticed was that of the middleman; it seemed to him a very difficult problem to solve, and scarcely one which the Government should interfere in. He could not agree with those who advocated such a course. These things worked gradually, and as education and intelligence increased, the native craftsmen would be able to maintain their own, and by degrees establish communication with the tradesmen or middlemen, which would be the means of increasing the demand for labour. Mr. Powell had laid great stress on the tendency to degeneracy in art by imitating European ideas, and it was a matter of great importance that all those who had anything to do with the encouragement of the handicrafts of the country should endeavour to prevent such mistaken imitations. He recollected once requiring a carpet for his own use; he sent out to India that one might be made; he was asked to name the colours, and mentioned the three primitive colours, leaving the pattern to the native designers. In order to please the Christian probably, the carpet came back with a pattern of lozenges, and inside each lozenge was a cross, but no attempt at anything like a Persian or Indian pattern was made. He could quite bear out what had been said as to the house decoration of the natives. It was lamentable to see the paltry Birmingham ornaments and tawdry pictures in the palaces and houses of the Rajahs and natives of position. They could no more be called works of art than a pea-shooter could be looked upon as an Armstrong gun. He thought great good would come from this paper, and the Exhibition at South Kensington to which it would form a useful handbook. Mr. Powell had alluded to the increase in the country consumption of home manufactures, but the view might be extended, and he would give a few figures showing the increase which had taken place in the export of Indian manufactures to other countries. Looking through the trade returns he found that, taking some of the principal articles now manufactured by steam machinery, they had increased considerably, the figures being as follows:—

Cotton Twist.

	£
1875, total exports	147,000
1885, ,, ...	2,440,000

Cotton Manufactures.

1875, total exports	364,000
1885, ,, ...	897,000

Jute (which was hardly known, and certainly not grown, in India until the time of the Crimean war).

1875, total exports	238,000
1885, ,, ...	1,500,000

Silk.

1875, total exports	230,000
1885, ,, ...	328,000

The value of the whole of the manufactures exported from India last year was £5,960,000, which was about $7\frac{1}{3}$ per cent. of the whole exports of Indian produce. Only about £1,000,000 of that came to this country, the greater portion being taken by China, Japan, the Straits Settlements, and even the United States. The import of cotton goods from England into India did not appear to have been materially affected by the export of Indian manufactures, for in 1875 they amounted to £19,000,000, and in 1885 to £24,500,000. What was mainly wanted in India for the increase of its manufactures was the development of its coal resources, and the increased use of steam machinery. In time, by means of railway communication, coal would reach many places in India which would be suitable for manufactures, and he thought the time would arrive when India would be looked upon not only as an agricultural, but also as a large manufacturing country. It contained all the materials for that purpose, and there was no reason why, with the application of capital, and the introduction of machinery, that should not ultimately take place.

The vote of thanks was carried unanimously.

TWENTY-FIRST ORDINARY MEETING.

Wednesday, May 12, 1886; Sir EDWARD BIRKBECK, Bart., M.P., in the chair.

The following candidate was proposed for election as a member of the Society:—

Smith, Albert Mervyn, Bangalore, India.

The following candidates were balloted for and duly elected members of the Society:—

Bidwell, Miss, 11, Hyde-park-place, W.
Curwen, J. Spencer, Forest-gate, E.
Hebson, Douglas, Tower-chambers, Liverpool.
Hookey, James, General Post-office, E.C.
Mount, George, 5, Belsize-park-gardens, N.W.
Salmon, James, 21, Finsbury-pavement, E.C.
Thompson, Charles, St. Ninian's-house, Leighton-crescent, Brecknock-road, N.W.
Watson-Will, William, Ossory-villa, Ossory-road, S.E.
Wightman, Charles, 151, Fenchurch-street, E.C.
Williams, Thomas Henry, Bank-house, Garston, near Liverpool.

The paper read was—

THE PROPOSED FISHERY DEPARTMENT FOR ENGLAND AND WALES.

BY J. W. WILLIS-BUND.

Not the least of the many services that Sir Edward Birkbeck has rendered to the fisheries of England and Wales, was to obtain the assent of Government to his motion for a central department charged with the care and control of all the fisheries. It is hardly credible that, at the present time, a country like England, which, both as a source of food supply and as a nursery for her sailors, depends so much on her fisheries, has not only no Department of State to whose care they are entrusted, but absolutely no reliable returns to show what is their true state and condition. While the German Government think no detail too small to be worked up and investigated in connection with its fisheries; while the Norwegian Government give returns as to their annual take of fish; while the United States profess to know the value and productiveness of their fisheries to a cent. and a sprat, England is contented to rest not only without the knowledge of what her fisheries are, whether they are increasing or diminishing, but also without even taking steps whereby such knowledge may be acquired. Indeed, so dense is the ignorance that when, in 1879, one of the numerous Commissions inquired into the English sea fisheries, they, after visiting some fifty-two places and occupying over a year in their inquiries, professed themselves unable to give with accuracy, not a a return of the weight or value of the fish caught in any year, but a list of the boats engaged in fishing! In the report of 1879, the Commissioners thus express themselves:—

> "During the course of our inquiry we have again and again been struck with the enormous difficulty of obtaining any reliable statistical facts relating to our sea fisheries. We publish in an appendix the best account we have been able to procure of the number of fishing boats, but we fear that the account is almost hopelessly imperfect."*

By accepting Sir Edward Birkbeck's proposal, Government have admitted that this state of things must no longer be tolerated, but we are still in ignorance as to what steps are to be taken to remedy the evil—those we shall only learn when we see the Government Bill. As, however, it is doubtful when that Bill will be introduced, and as it may only be brought forward and rushed through at the end of the Session, when there will be neither time nor opportunity to discuss its provisions, it seems desirable in the interests of the fisheries to arrive at some conclusion as to what it should and what it should not do. This is especially necessary, as I venture to think that the real objects for which such a department is sought to be established are hardly understood, and therefore it is very desirable to remove, if possible, the objections and prejudices that may exist against the scheme.

At present the fisheries of England and Wales have relations with at least five different Government departments. Salmon, wherever they may be, trout, char, and such freshwater "fish as do not migrate to the open sea," are said to be looked after by the Home-office; oysters, crabs, lobsters, mussels, and bait fisheries by the Board of Trade; other sea-fisheries, so far as they are looked after at all, if in English territorial waters, are under the Board of Trade, if outside that limit, under the Foreign-office and the Admiralty; while fish that are landed in English ports fall under the purview of the Customs. Solomon is reported to have said in the multitude of counsellors there is safety, and if by safety he means neglect—the saying applies equally to Government Departments. Nothing is done, and if you want anything done it is almost impossible to know to which Department to apply. Let me give two instances taken from official Blue-books. The Sea Fisheries Commissioners, 1879, to which I have already alluded, complains* that one of the great grievances of the North Sea Fishermen was that Dutch fishing-boats were not compelled to be numbered, and this they reported to the Home-office, but the Home-Office have nothing to do with sea-fishing boats or their numbers; that belonged to the Board of Trade, so the Home-office reported the matter to the Board of Trade. What the Board of Trade did I cannot state. I presume sent to the Foreign-office, or acknowledged the receipt of the Home-office letter. Had there been a Fishery Department it would have been its duty at once to communicate direct with the Foreign-affice to get the regulation made. The usual correspondence between two departments of State, ending usually in correspondence, would have been avoided. The next instance is more striking. It was deemed desirable to make inquiries into the herring fisheries. In the second report of the Scotch Fishery Board the following statement appears:—

> "Dr. Buys-Ballot invited those engaged in the herring fishery to make observations in order if possible to ascertain the circumstances likely to lead to the most profitable fishing, as well as to enable them to make a herring chart. This was followed by the Board of Trade issuing instructions for the collection of herrings from all parts of the coast of Scotland, wherever they could be fallen in with, at different periods of the year, observations being noted with each sample according to a form which had been revised by Professor Huxley, F.R.S. Twelve boxes of samples were in this way collected and forwarded to the Board of Trade along with the relative observations; but there is no record of the samples having been submitted for examination."

The Board of Trade did its duty in collecting the samples, there was no obligation on that Department to make use of them when collected. As long as this divided authority continues, each Department will do its duty and no more; it is not the object of one Department to help any other. If the Home-office had required the herrings, they could have had them for asking. Why should the Board of Trade send them?

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* "Sea Fisheries Report, 1879," p. xxxii.

* p. xxx.

I could give other examples, but the two I have cited will suffice to show that the diversity of departments does not tend to promote the interests of the fisheries. Another great evil that arises from having separate fisheries looked after by separate Departments, is that rules and regulations are made for one class of fisheries, wholly regardless of the effect they may have upon other fisheries. To give one instance. The limits of the Carmarthen Bay fishery district were approved, and a scale of licence duties for salmon sanctioned by the Home-office; but no one considered what the effect of the licences would be on the mackerel or other fisheries within the three-mile limit, and the result was, that the rules intended to apply only to salmon applied also to the mackerel fisheries, and these last were legally liable to take out salmon licences, or else give up their fishing, and in the result, some ten years after these rules had been made, the Secretary of State had to order an inquiry into the effect of these rules on fisheries for sea fish other than salmon. If there was a single Department that dealt with the fisheries as a whole, and looked at every regulation that was proposed, not from the mere point of view of any one fishery, but of all the fisheries, such a case as the one just cited could not occur. There is another disadvantage from divided authority. We are all supposed to know the law (fortunately for us lawyers it is merely a theory), but in fishery matters not only does no one know the law, but I do not think it is possible for anyone, with the best intentions, to acquire a knowledge of it. There is no place, not even the library of the British Museum, where all the different regulations relating to our fisheries can be found. Conventions with foreign Governments may be found at the Foreign-office, rules as to freshwater fish at the Home-office, rules as to crabs and oysters at the Board of Trade; but when you have searched all the offices, and done all in your power to find out what the law is, you may as likely as not find that the very thing you were looking for exists, but does not come within the province of any of the Departments at which you inquired. I once had to advise on what was the law as to the capture of smelts at a particular place. I imagined I had most of the fishery law noted up, but I could find nothing about smelts. So I went to the Home-office — they were profoundly ignorant of smelts except when cooked. I went to the Board of Trade—they, I found, knew nothing about the matter, but tried to conceal their ignorance by great civility, and by referring me to various rules under the Piers and Harbours Act, saying I might find something there; that was true, but it was not smelts. I went to various libraries and places, and had almost come to the conclusion that the smelts were outside any law, when, as a forlorn hope, I suggested that my client should search the bye-laws of the borough where the fishing took place; he did so, and there found an elaborate bye-law as to the sale of fish, including smelts, approved by another Government Department, the Local Government Board. If we get a Fishery Department, one of its duties should be that all rules as to fish and fishing should be collected there for reference. These are, perhaps, minor matters (though very important in connection with the administration of the fisheries) compared to supplying the great want—an annual statistical account of our fisheries. At present we have nothing of the kind. It is true the Board of Trade have begun to publish some returns of fish landed in England, but these returns are by no means perfect; they show the quantity of fish landed, but they do not show the source from whence the fish has been obtained. It may very well happen—indeed it does happen—that the return includes foreign fish. It is, of course, an interesting fact to know what fish is imported into the country, but that is not what is required; for the present purpose we want to know the annual yield not of imported fish, but of British fisheries. If we did, we should then get some means of knowing whether our fisheries were improving or not, and whether there is any fear that the fish supply is failing us. At present we have nothing to show us the annual take. We do not even know if the salmon fisheries are holding their own, for, out of the forty-five Fishery Boards, twenty-one make no return as to the take of fish, and we have no real evidence to show what is the real annual value of those fisheries; of course guesses can be made, but they are only guesses, and what we want are facts, to show that the result of all our legislation and all our rules is the improvement of the salmon fisheries; and until we get some accurate statistics, we shall be unable to find out. What is true of a branch of the fisheries like the salmon, is still more true of the great fisheries like the herring and cod. Complaints are often made that the fisheries are falling off; we are always told it is not so, but we have no evidence to show it is not beyond vague statements. I will cite two instances—one as to herrings, the other as to cod—and it will be seen on what very insecure ground our confidence is based. First, as to the herring. In the "Sea Fisheries Report" for 1879 this passage occurs:—

> "It is stated in the report of the Herring Fishery Commission, 1878, that 2,400,000,000 herrings are caught annually by the British, French, Dutch, and Norwegian fishermen. It is estimated that at least fifty times as many herrings are caught by other enemies of the fish. In that case more than 120,000,000,000 must be annually destroyed in the seas adjoining the United Kingdom. It is a very moderate statement to say that one herring survives for every herring that is destroyed, and it is a very fair inference that one half of those that survive are female fish, and that 60,000,000,000 female herrings are left to deposit their roes in these seas. A herring carries 30,000 eggs—place her eggs at only 20,000 and the 60,000,000,000 herrings must produce 1,200,000,000,000 eggs. The mind of man is hardly capable of following these huge figures, and we will accordingly try to reduce them to some more intelligible standard; 500 adult herrings might possibly be compressed into a solid cube of one foot, assuming the 1,200,000,000,000 herrings grown to maturity they might possibly be compressed into 2,400,000,000,000 cubic feet, in other words a solid wall, about 200 feet broad and 100 feet high, reaching round the greatest circumference of the earth."

This "huge" statement is published by authority, and it is on such statements—I will not call it evidence—that we are told to believe in the prosperity of our fisheries. It is often said that you can prove anything by figures, and there could not be a better example than this. It rests upon two assumptions, one of which can I think be demonstrated to be untrue, and there is no evidence as to the truth of the other. As to the first, all the herring eggs do not hatch out, all those that hatch out do not become full-grown herrings; this we know, there is no evidence to show that half a given number of herrings are females; when the truth of these two statements go the whole of the assumption, and the conclusions that are drawn from it go also. I say we have evidence that all the eggs do not hatch out. I have only to cite Professor Cossar Ewart in his account of the natural history of the herring in the second report of the Scotch Fishery Board, at p. 66, speaking of the celebrated Ballantrae Bank, he says:—

> "This pollution (from nets that had been lost with fish in them) would be continued and extended by portions of the nets continuing to fish throughout the whole season, so that not only might the eggs which might have been first deposited have been destroyed, but fish which might have spawned at some other part of the bank would be taken, and the eggs, though shed, rendered useless, for although portions of the lost nets secured were thickly coated with eggs the eggs were never developed, they had probably never been fertilised. In this way the greater part of a shoal might be destroyed, and, what is of even greater importance, nearly all the eggs deposited during the spawning period might also be destroyed, so that only a comparatively small brood would be hatched."

I might cite a number of other ways in which is shown that only a small per-centage of fish eggs spawned are ever hatched out. Speaking of trout eggs, an authority (Mr. Andrews, of Guildford) says he believes, in a natural state, 99 per cent. of the eggs are lost, and what is true of the trout in fresh water is equally true of the herring in the sea. The question is really of importance, as the public confidence in the inexhaustible nature of our fisheries is drawn from such official reports as these—reports that make one think how a cruel fate has diverted their authors from their real vocation in life. Imagine, but for a moment, if, instead of compiling dry matter-of-fact Blue-books, the authors had devoted themselves to framing prospectuses for joint stock companies, what splendid arrays of figures we might have seen.

As to the cod. In Mr. Huxley's inaugural address at the meeting of the Congress at the Fisheries Exhibition in 1883, this passage occurs:—

> "I believe that it may be affirmed with confidence that, in relation to our present modes of fishing, a number of the most important fisheries, such as the cod fishery, the herring fishery, and the mackerel fishery, are inexhaustible. And I base this conviction on two grounds: first, that the multitude of these fishes is so inconceivably great that the number we catch is relatively insignificant; and secondly, that the magnitude of the destructive agencies at work upon them is so prodigious, that the destruction effected by the fishermen cannot sensibly increase the death-rate. At the great cod fishery of the Lofoden Islands the fish approach the shore in the form of what the natives call cod mountains—vast shoals of densely-packed fish, 120 to 180 feet in vertical thickness. The fish are so close together that Professor Sars tells us the fishermen who use lines can notice how the weight before it reaches the bottom is constantly

knocking against the fish, and these shoals keep constantly coming in, one after another, for two months, and all along the coast. A shoal of codfish of this kind, a square mile in superficial extent, must contain at the very least 1,200,000,000 fish. (This allows over four feet in length for each fish, and a yard between it and those above and below and at the sides.) But it is an exceptionally good season if the Lofoden fishermen take 30,000,000 cod, and not more than 70,000,000 or 80,000,000 are taken by all the Norwegian fisheries put together. So that one fair shoal of all that approach the coast in the season must be enough to supply the whole of the codfish taken by the Norwegian fishermen, and leave a balance of 40,000,000 or 50,000,000 over."

Statements like these are, to my mind, very unsatisfactory. Mr. Huxley states that the fisheries are inexhaustible, and instead of giving the evidence upon which he bases his statements, cites a statement by an eminent Norwegian authority; but here, again, we have not before us the facts upon which Professor Sars' statement is based. When you examine the statement, it merely comes to this—Mr. Huxley thinks our sea fisheries are unexhaustible because Professor Sars says the fishermen tell him something. I do not know if Norwegian fishermen have a less tendency to exaggeration than Norwegian sportsmen, but I must say the statement reminds me of what a Norwegian sportsman once told me as to the quantity of duck in a certain fiord where we were going to shoot. He said, "When you get there (we were in a steam-launch), we shall have to go slowly, to avoid running over the ducks." I expected to see, I don't say enough ducks to stop the launch, but a considerable number, In the result, we saw two! I must confess that it is with a very grave suspicion that I regard statements as to numbers without seeing the evidence to support them, and still more do I distrust figures founded on such statements. These computations are, to my mind, always to be taken with more or less margin. I will cite another example as to salmon fisheries: it appears in the thirteenth report of the inspectors of salmon fisheries, speaking of one of the tributaries of the Eden, the Caldew. The effect of the loss to the river by a week's flood preventing the fish spawning, is thus given:—

> "Two hundred fish attempt to spawn in the Caldew. We will suppose half the fish to be females, carrying 1,000 eggs each to each pound of her weight, at the average of 10 lbs. each fish, they would have produced 1,000,000 eggs; deduct half for eggs lost and destroyed, 500,000 eggs; deduct half again for fry killed, leaves 250,000; deduct half again for smolts killed, 125,000; deduct half again for smolts killed, 62,500; deduct half for accidents, leaves 37,250, average each salmon at 5 lb. weight at 10d. per lb., and we find the approximate value of salmon at the lowest calculation lost by the present state of the one mile and a quarter of the Caldew is no less than £6,510 8s. 4d."

This, like the others, is a fair specimen of the way in which the public are informed of the value of our fisheries. *Omne ignotum pro magnifico.* It is a beautiful instance of counting your chickens before they are hatched; if it is carried out it gives rather startling results, £6,510 represents a mile and a quarter, £5,208 is the value of a mile, but the Eden, of which the Caldew is a tributary, has at least forty miles of like water, so that the value of the Eden is £208,320, or more than all the English and Welsh fisheries. It is necessary to be continually on one's guard against official figures and results thus arrived at; they are worse than misleading, they are positively harmful, and it is most urgent we should get as soon as possible accurate and reliable figures.

If we had reliable statistical information we might dispense with those constant inquiries that are made either by means of a Royal Commission or by a Government department at frequently recurring intervals, that usually only lead to a large expenditure of public money and no real results. I wish to speak with every possible respect of Royal Commissions, but it is rather difficult to do so when one comes to read their reports, for it frequently happens that different Commissions arrive at conclusions that, to put it mildly, do not coincide, and this fact somewhat lessens the belief in their value. But a departmental inquiry is even worse than one by a Royal Commission, for as the gossip they call evidence and on which they act is not, except under the Sea Fisheries Act, given on oath, the limit of the statements of the witnesses is ordinarily the limit of the credulity of the persons holding the inquiry, and one of two results follows, either a report based on what are obviously unreliable statements is made; or the person holding the inquiry adheres to his preconceived opinion, for his experience of previous inquiries tells him that all men, especially fishermen, are liars, so he pays no attention to the so-called evidence, and reports in accordance with his previous views. Another thing which tends to bring discredit on these local departmental inquiries is that they are often obtained for a specific purpose, and the persons obtaining them of course desire by strong but unsworn assertions, to make good their case and prove they were justified in asking for the inquiry. It is always an easy way to shelve a difficult question to have an inquiry and not to act on the report. I recollect a case where politics were the only reason that caused the inquiry to be made. A gentleman had been returned as member for a constituency: he had promised in his canvass, if he was returned, something should be done to do away with some very wholesome provisions of the Salmon Acts to which his constituents objected. Unlike many Parliamentary candidates, he kept his word, and prevailed on the then Secretary of State for the Home Department to order an inquiry which was in effect an inquiry whether it was not desirable to legalise poaching. Even when an inquiry is necessary, and is properly held, it by no means follows that the results are satisfactory. I recollect a case at which the persons appointed took evidence, and went through the farce—I use the term advisedly—of of listening for three days to witnesses and the speeches of counsel, and at the conclusion intimated what their views were. A gentleman who was not present at the inquiry met them, after the inquiry was over, and told them various matters, and showed them some old county history. When their report was published, it did not profess to go on the evidence heard at the inquiry, but what had been gleaned from the gentleman and the county histories.

But worse than this was a case of which I only know from a newspaper report; it took place last year at one of these inquiries—it is only fair to say not before an inspector. After hearing some evidence the meeting broke up in disorder. Yet it is on the results of these inquiries that the regulations of our fisheries are made; it is on the so-called facts alleged to be proved at them that we are told our fisheries are prosperous, and we have no reason to fear over-fishing. In many cases, if there were carefully arranged statistics of the fisheries, these scandals, for that is what they really amount to, might be avoided, as the department would have the information that would obviate the necessity for the inquiry.

If the result of the establishment of a fishery department was only to bring about the three points I have mentioned—one office to deal directly with all fishery matters, one place where all the rules that regulate the fisheries could be ascertained, and one place were accurate information as to the fisheries was obtainable, a very great step would have been made in fishery reform.

But there is another point as to which the work of such a Department should be directed—the scientific part of the fishery question—and here it is that the great opposition to the scheme will arise. I venture to think if such an opposition arises it will be because the question is not understood. No one is more opposed than I am to an increased staff of Government officials, whose duty it would be to meddle and muddle. Scientific experts are delightful persons when you have not to pay them. Are such experts needed by the fisheries? So far as my experience goes I feel tempted to say, no, and that if a scientific expert was at the head of the Fishery Department, it would be worse than a lawyer. The expert has ideas and theories, and if you do not agree with him you are not fit to live, and this prevents practical work being done. I venture to think the duty of a Fishery Department is not to employ experts to solve problems, but to collect the data that may enable the experts to solve the problems as they arise. For instance, if the Department annually published a full report to Parliament containing complete statistics of the take of fish, the time of the appearance of the fish, the different conditions of temperature, tide, wind, and weather, under which the fish were taken, the normal or abnormal appearance of any fish, and any other information that might be collected, any scientist could form his own conclusions and deductions from the published facts; but if the Department merely published Mr. A. or Mr. B.'s report on the facts, it would only, at a considerable expense, give the individual opinion of Mr. A. or Mr. B, which might or might not be of value. But, worse than this, it does happen that when you have scientists engaged in fishery matters, they do not always agree on the facts. For example, in the second annual report of the Scotch Fishery Board, there is a most interesting paper on the "Chemistry and Histology of the Digestive Organs of Fishes;" at p. 55 there is this statement—

> "There is a popular belief that the herring does not feed during the spawning season, but this I regard as a mistake, as one always finds a certain per-centage of herrings with food in their stomachs during January and February." This much seems certain, they do not

feed so voraciously when the ova and milt are reaching maturity."

This was published in 1884. In 1885, in the 24th Report of the Inspector of Salmon Fisheries (England and Wales), we get, at p. 25, this statement—

> "There is one period in the life of the fish, the so-called matie condition, during which the herring feeds voraciously, grows, and finally lays up a great stock of nutritious matter, while the reproductive organs remain rudimentary; and this is followed by another period during which the fish leaves off feeding, while the reproductive organs attain an enormous size at the expense of the nutritive matter previously stored up in the body."

We have here two statements of fact by two distinguished scientific men—both put forward under State authority—one of which must be incorrect. If we had the facts on which these gentlemen arrived at their conclusions as to the feasting or fasting of the herring while in an interesting state, we could draw our own conclusions, which would be more satisfactory than contradictory dogmatic statements.

What I venture to think the Fishery Department should do, is to collect and publish facts, leaving each person to draw his own conclusions. In studying law, one used to be taught never to trouble about what the law was until you had accurately grasped all the facts of each case; and the rule seems equally to apply in science: never trouble about the scientific bearing of facts until you have collected all the facts having relation to a given subject.

If the Department will only publish accurate statistics, there are plenty of persons who will devote themselves to the task of drawing conclusions from the facts. For example, there is in the second report of the Fishery Board for Scotland a diagram, showing the progress of the herring fisheries from 1809 to 1883, by showing the number of barrels of white herrings cured in each year. This chart shows that the take of herrings rose from 90,000 barrels in 1809 to 1,400,000 in 1880; part of the return 1809 to 1850 includes not only Scotland but part of England, and from 1821 to 1869 also includes the Isle of Man Fisheries, it therefore brings out this fact that the Scotch boats alone are now catching double the number of herrings than the combined catch of Scotch, English, and Manx boats in 1850. This may of course be regarded in two ways. From the optimist point of view it would be said this shows how prosperous our fisheries are; from the pessimist, it would be said we are drawing too largely on our supply, and are, in fact, over-fishing; but if for the next series of years we find that the supply of herrings still keeps up, then it would furnish better evidence that the increased fishing was doing no harm than any number of Royal Commissions or departmental inquiries. The return also brings out other interesting facts. To take two, certain years are far more productive than others—1880 was half as productive again as 1879, while 1879 was half as productive again as 1876; one point that it would be most important to ascertain is, what are the natural conditions of a productive year, temperature, weather, tide, wind? Is there anything that can be observed to account for it? Anything that is absent in a bad year? Again, does a good year in Scotland mean a bad year in England, or do the good years occur simultaneously both in England and Scotland? Complete English statistics could alone show that. It would also be very interesting to know if a good year of herrings was also a good year of other fish, or whether a good year of one sort of fish was a bad year of another. Another point appears from the diagram, that it seldom happens that two good years occur in succession; that it seems as if a good year was a distinct effort, and that it took time to again bring about the same state of things.

A good year in the salmon fisheries is often followed by a sharp drop, and it takes one or more years to make another good year. This appears to be so if the produce of all the English and Welsh rivers is taken. I have noticed the same state of things on the Severn, but in a more marked degree, and had written as follows with regard to the Severn before I saw the Table as to the other rivers:—

> "The Severn Table seems to point out that a good year is a distinct effort for the river to make, and exhausts it for a time. One or two years seem to lead up to it, then afterwards for a year or two there is a falling away. From the Table, 1870, 1876, and 1883 all point this way; after 1870 there was a falling off for three years before the effort was recovered. It took three years to lead up to 1876, then there was a fall for three years, and it took three years to prepare for 1883."

The first part of the Tweed returns confirms this. It took some six years to prepare for the great year 1816. Unfortunately, since 1848, the take of fish in the Tweed has so fallen off, that it is almost impossible to use the return for comparison. From the returns in the reports of the Scotch Fishery Board, I have constructed a diagram as to the cod, ling, and hake fisheries. It extends from 1826 to 1884, and for part of that time, until 1850, included some of the English fisheries, and, until 1869, the Manx fisheries as well. Here, though perhaps not to the same extent, we get the fluctuations in the different years that were noticeable in the herring and salmon returns. A good year is, as a rule, followed, if not by a bad, by at least a moderate one.

When the cod return is compared with the herring, we find that the take of fish has been steadily increasing year by year, and it is a point for consideration if the development of the two branches of fishing, side by side, does not go far to lessen any destructive effect human agency may have on the supply of fish. One of the great enemies to the herring is the cod, and if it is true our capture of herrings has enormously increased, it is likewise true that our destruction of their enemy—the cod—has increased also. It may well be that the shoals of herrings sustain no greater actual loss than they did in former years, but that man is substituted for fish as the captor of the herrings.

Although no accurate statistics exist as to the value of the English fisheries, it would hardly be right to pass over them without making some attempt to guess at their value, so that some idea may be formed of the importance of the work that the new Department will have to undertake.

I do not propose to give chapter and verse for my figures, I have drawn them from a number of sources more or less accurate, and I must ask that they be taken merely as an estimate, and like most estimates, I believe them to be under rather than over the mark.

The herring fishery is the most valuable. At Yarmouth alone, some 10,000 lasts of herrings are annually landed. A last of herrings contains nominally 10,000 fish—usually more, for herrings are counted 132 to to the 100; therefore, at Yarmouth alone, something between 150,000,000 and 200,000,000 herrings are taken annually. But Yarmouth, though the great centre of the herring trade, is not the only place where herrings are caught round the British coast; if we assume—and I admit I have no evidence on which to base the assumption—that Yarmouth equals the take of all the other British herring fisheries (I leave out pilchards) we have a total of 400,000,000 herrings a year.

Next to the herring comes the pilchard fisheries. Pilchards are sold by the hogshead, a hogshead contains, on an average, about 3,000 fish, about 10,000 hogsheads represents the export of pilchards from Penzance and Falmouth, something like 30,000,000 a year. The trawl fisheries are practised all round the coast, but Grimsby is to trawling what Yarmouth is to the herring fisheries. It is the home of the English North Sea trawlers, and it is said that 30,000 tons of fish are annually landed there.

Next come the line fisheries they are practised all round the coast, but it is almost impossible to give any figures as to the quantity of fish taken by them. Then come the crab and lobster fisheries, the shrimp, mussel, and cockle fisheries. Here, again, one has to guess at values, but they must be something very considerable; Buckland estimates the Morecambe Bay cockle fishing to be worth £14,000 a year; and the Carmarthen Bay £15,000. The shrimps at Morecambe Bay he puts at £4,000 a year. The Thames whelk fishery at £8,000.

If this is anything like correct, the value of shell fisheries must be larger than usually supposed, the lobsters, crabs and oysters must be £50,000 and the other fisheries nearly the same, so that about £100,000 a year would represent the shell fisheries.

As a guide as to the value, we may take the figures given by the Scotch Fishery Board for 1883 and 1884.

	1883.		1884.
Cured Fish.			
Herrings	£1,904,118 15s.		
Cod or Ling....	191,468 0s.		
	£2,095,586 15s.	..	£2,279,615
Fresh Fish.			
Haddock	£340,693		
Herrings	149,433		
Cod and Ling	97,297		
Flounders and flat fish	29,194		
Other kinds..........	78,093		
	£684,710	..	£716,295
Shell Fish.			
Lobsters	£32,966		
Crabs	19,716		
Mussels	16,548		
Oysters and others....	13,755		
	£82,985	..	£80,939
Salmon	£350,000	..	£275,000
	£3,286,242	..	£3,301,849

If for the English fisheries we put the cured fish at £1,500,000, the fresh fish at £500,000, the shell fish at £100,000, and the salmon £190,000, we shall probably be within the mark, and this gives for the English and Welsh fisheries a total of £2,290,000, and probably from £2,000,000 to £2,500,000 would be about the annual value.

Before I pass on to say how these fisheries should be managed, I should like to say one word on the present state of the salmon fisheries. The salmon has always been the *enfant gâté* of fishery legislation, and every one imagines himself competent to talk and write on the salmon fisheries. I am afraid that much of what has been written is pure speculation, but I am also afraid we have never really realised in how bad a way our salmon fisheries are. There is always the same rose-coloured appearance about official fishery reports that there is about the reports of anglers and others who have been fishing. Having regard to some of the things I have stated, it ought not to astonish us that the salmon fisheries are not over prosperous, but I think few people really realise their real position. I will give three facts that seem to me to speak volumes.

1. There is no river in England and Wales where each rod-fisherman on the present return catches a yearly average of ten salmon.
2. The number of boxes of salmon sent from the Tweed alone to Billingsgate in the year 1883 was more than the whole supply sent from all the English and Welsh rivers.
3. If four rivers are left out—the Tyne, the Eden, the Tees, and the Severn—it is doubtful if an average of 100,000 fish a year are caught in England and Wales.

For the proof of the first I must refer you to the diagram on the wall, which I have made out from the replies in the Inspectors' reports. As to the number of salmon caught in each district by rod and line for the last five years, it will there be seen that the chance of each individual rod licensee catching a salmon are certainly not such as to justify the expenditure of £1, which is the usual charge for a license.

In proof of the second, I will give the figures. They will be found at page 2 of the 23rd annual report of the Inspectors of Fisheries. From all the English and Welsh rivers, 2,271 boxes were received; from Berwick-on-Tweed, 2,278. This fact should be taken in conjunction with the opening sentence of that report. "Generally speaking," says Mr. Huxley, "the salmon fishing season of the year 1883 was the most productive recorded for many years, the return from many districts showing that more salmon were taken than in any previous season since the present salmon law came in force."

The third point is not capable of exact proof, for the reason that all the districts do not give a return of the fish they catch. I have, however, arrived at it in this way. The returns given in the 24th report, which gives the total number of salmon caught (I am leaving out migratory trout) in England and Wales in 1884, is 81,938; of this the Severn returns 20,000, the Tyne 21,216, total 41,286. The total number caught in 1885 was 74,410, of which the Tyne caught 20,871, and the Severn 20,000. These are the two best rivers that make a return. That brings down the number from the other returning districts to 40,652. I am quite aware that several of the returning districts only give the rod-fish. I do not, however, think I shall be very far out if I put the other returning districts at 18,000; that would make 58,000. Of the non-returning districts, the Couquet has nearly no salmon, the Wear may be put down as 200, the Canterbury Stour, Rother, the Sussex, Ouse, Frome, and Otter do not profess to catch salmon; 2,000 for the Exe, 1,000 for the Teign, 2,000 for the Dart, 1,000 for the Tamar and Plym, 500 for the Fowey, 500 for the Camel, 5,000 for the Taw and Torridge, 10,000 for the Wye, 20 for the Rhymney, Taff, and Ely, 200 for the Cleddy, 3,000 for the Teifi, 25 for the Ayron, 2,000 for the Dyfi, 500 for the Dwyfact, 5,000 for the Lune, 2,000 for the Kent, and 5,000 for the Derwent, are probably a liberal allowance. And this makes between 95,000 and 100,000.

At first sight 100,000 seems a large number, but when we remember that in the Tyne alone, in 1872, 129,000 salmon were caught, it comes to this that if we except four rivers, the produce of all England and Wales does not equal the Tyne at its best. But it will be said if the Salmon Acts have produced those four first-rate rivers, it is something. I admit it is something, but not very much, and it is very doubtful if those rivers are keeping up to the standard they once attained; for if we study the return, we find the Tyne take has been gradually decreasing, the Eden has suffered severely from disease, the Tees find it necessary to keep up the stock of fish by artificial breeding, while the Severn has had a succession of bad spawning seasons that must ultimately affect the stock of fish. I am, therefore, by no means sanguine that we shall see, for the present, the take of salmon in England and Wales reach an average of 200,000 fish a year. This may seem a large amount, but, with the exception of one or two years, it is barely two-thirds of the average number of fish sent from Scotland to Billingsgate.

The question that remains to be considered is, how is the new Department to be constituted? and here I am afraid I shall be at variance with some of my fishery friends. I have always been, and still am opposed to the expenditure of large sums of public money in aid of the fisheries, and I object very strongly to the proposal for considerable State aid. It seems to be forgotten that State aid means State inspection, and if gentlemen have had much experience of fishery inspection, they will agree with me that State aid can be had too dear. I speak from an experience of a quarter of a century in fishery matters, and I say advisedly that, so far as I know, the inspectors of fisheries have done nothing for the district with which I am connected. If the fisheries improved, or anything was done that was successful, they took the credit; if the fisheries did not improve, and the works were not a success, the Board got the discredit—the *sic vos non vobis* doctrine was remorselessly applied. For the last four years, I am bound to state, we have not been honoured by the late inspector's patronage. During his term of office Mr. Huxley visited us once to explain why he disallowed some bye-laws, and he once sent his assistant to give evidence against the Board in favour of the law-breakers, when the Board were trying to carry out the law. It will, therefore, be obvious that my experience of inspectors is not a happy one. It is a bold thing to do to sketch out the details of a plan for the future management of our fisheries, but, as I have dwelt so much on the evils of the present system, I may be fairly asked to say what should take its place. I think something of the following kind would meet the present requirements. A single Department, presided over by some first-rate official, to whom control should be committed of all the fisheries, inland, coast, and sea, of England and Wales. This official should do what inspection was required, that he might make himself practically acquainted with the working of the fisheries. He should have such a staff of clerks—it would not necessarily be a large one—as might be required to tabulate and digest the information that was collected, such information to be given as fully as possible in annual reports to Parliament.

The local work to be done through local Boards. At present many of the fishery districts extend to the three mile limit (seawards I would extend all to that limit), or to the utmost extent of territorial waters, and I would make them look after all fish, not only particular kinds. I am quite aware the constitution of the Boards would have to be altered, but it is not so perfect now that we need fear alteration. The central authority should require the local Boards to collect information on the different points connected with the fisheries. It should not be, as now, a set of questions sent out asking what they had done, but a set of orders saying what they were to do; and here, I think, State aid might come in; if the cost of those inquiries was more than the Local Board could afford, a part might be repaid by the State. Instead of a license for one kind or for different kinds of fishing, I would require a license for all, and I believe the funds thus raised would go a long way to meet the expenses.

I shall of course be told that the whole of England and Wales is not included in the fishery district. This is true, but by the time the freshwater districts are formed, there will be very little not so included; and if power is taken to extend the districts, or if necessary to make coast and sea-fisheries districts, the local authorities will soon be constituted. By some such scheme as this you will get a series of local authorities all over the country, entrusted with the duty of carrying out the law and developing the fisheries; and, without imposing any great charge on the State, you would, by means of licenses for fishing, raise the greater part of the necessary funds. There is one other point I should like in some way to see carried out, namely, that there should be some persons having a practical knowledge of fishing, who have a recognised official position, whose duty it would be to consider any question of bye-laws and rules, and to frame the general policy of the Department. Either they should be representatives for the different classes of fisheries, as say, the herring fisheries, the trawl fisheries, the line fisheries, and the inland fisheries, or for localities, as representatives, say, for the South of England fisheries, the Welsh, the East and the North coast fisheries. I do not propose that these representatives should be paid, or that their consent should be required to any mere administrative duties, but that they should have a voice in determining the main lines of policy on which our fishery administration would be conducted. Of course the scheme I have mentioned is only an outline, and may be various details would have to be supplied. It consists of Local Boards, supervised by a Central Department, the Boards managing as far as possible their own affairs, but carrying out any directions of the Central Department. I believe that, to a great extent, the Local Boards would be self-supporting; the expense of the Central Department would, of course, have to be provided by the State.

Of course, the scheme differs from the Scotch Board or the American Commission, or any of the Foreign Government establishments, and differs chiefly in this, that the duties of the Department and Boards would be chiefly protective and administrative, and elsewhere they are scientific. As I have already said, I do not believe in setting up a scientific body to control the fisheries. By all means collect all the facts you can, so as to enable the rules for fishing to be framed upon definite principles, pay all heed to the results of scientific teaching, encourage independent scientific investigation, but do not allow one of the great sources of food supply to be administered on experimental principles. There are many doubtful points of policy in connection with our fisheries, but of one thing I have no doubt that, while it is most important to give every help to the scientific study of the fisheries, it is equally important not to subject them to scientific interference.

On the question of money there is one thing that is not sufficiently noticed, namely, that though our fisheries are more important, the State is now paying less money towards the English fisheries than formerly. We used to have two inspectors and special commissioners; the special commissioners were abolished, then one inspector was abolished. There used to be inspectors under the Board of Trade of oyster fisheries; this has been done away with, and now at last we have a single inspector and an assistant, and the whole sum voted is £1,178 a year.

I have occupied so much of the time of the meeting that I must leave unnoticed various points I should have liked to have referred to, such as the whole question of inland fisheries, the coarse fish, the angling interest. I can only, in conclusion, press on this Society, one of whose objects is to encourage national industries, the claims of that great industry that has done so much for the country, that is such a source of national wealth and greatness. I believe that, if only ordinary care is taken of our fisheries, not only may this industry be largely developed, but our food supply greatly increased, and from a native not from a foreign source, and that the first step towards bestowing that care and promoting that development is the establishment of a central Fishery Department.

APPENDIX A.—NUMBER OF BARRELS OF WHITE HERRINGS CURED IN EACH OF THE FOLLOWING YEARS:—

	Barrels.		Barrels.
1810 ..	90,185	1848 ..	562,743
1811 ..	91,827	1849 ..	644,368
1812 ..	111,519	1850 ..	770,698
1813 ..	153,488	*1851 ..	544,009
1814 ..	110,542	1852 ..	594,031
1815 ..	160,139	1853 ..	778,039
1816 ..	162,651	1854 ..	636,532
1817 ..	192,343	1855 ..	766,703
1818 ..	227,691	1856 ..	609,988
1819 ..	340,894	1857 ..	580,823
1820 ..	342,491	1858 ..	636,124
1821 ..	442,195	1859 ..	491,487
1822 ..	316,524	1860 ..	681,193
1823 ..	248,869	1861 ..	668,828
1824 ..	392,190	1862 ..	830,904
1825 ..	347,665	1863 ..	654,816
1826 ..	379,233	1864 ..	643,650
1827 ..	288,495	1865 ..	621,763
1828 ..	399,778	1866 ..	658,146
1829 ..	355,979	1867 ..	825,589
1830 ..	329,557	1868 ..	651,453
1831 ..	439,370	†1869 ..	675,143
1832 ..	362,660	1870 ..	833,160
1833 ..	416,964	1871 ..	825,475
1834 ..	451,531	1872 ..	773,859
1835 ..	277,317	1873 ..	939,233
1836 ..	497,614	1874 ..	1,000,561
1837 ..	397,829	1875 ..	942,980
1838 ..	507,724	1876 ..	598,197
1839 ..	555,559	1877 ..	847,718
1840 ..	543,945	1878 ..	905,768
1841 ..	557,262	1879 ..	841,796
1842 ..	667,245	1880 ..	1,473,600
1843 ..	623,419	1881 ..	1,111,155
1844 ..	665,359	1882 ..	1,282,973
1845 ..	526,032	1883 ..	1,269,412
1846 ..	532,646	1884 ..	1,697,077
1847 ..	607,451		

APPENDIX B.—NUMBER IN CWTS. OF COD, LING, AND HAKE, CURED, AND DRIED, IN EACH OF THE FOLLOWING YEARS:—

	cwts.		cwts.
1826 ..	69,136	1828 ..	82,515
1827 ..	95,161	1829 ..	81,321

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* Scotland and Isle of Man only. † Scotland only.

	cwts.		cwts.
1830	101,914	1858	95,596
1831	37,674	1859	118,383
1832	50,293	1860	115,688
1833	58,461	1861	82,344
1834	52,710	1862	100,657
1835	44,152	1863	129,725
1836	38,040	1864	107,758
1837	66,892	1865	112,807
1838	84,996	1866	115,819
1839	85,274	1867	119,638
1840	93,560	1868	113,831
1841	91,494	*1869	135,885
1842	76,849	1870	145,288
1843	77,707	1871	119,030
1844	62,813	1872	145,976
1845	83,914	1873	160,716
1846	92,323	1874	143,466
1847	90,783	1875	187,788
1848	81,624	1876	111,457
1849	85,462	1877	187,200
1850	98,903	1878	183,809
†1851	90,658	1879	162,365
1852	165,976	1880	155,745
1853	105,996	1881	115,513
1854	109,684	1882	121,337
1855	113,511	1883	120,335
1856	110,504	1884	174,506
1857	104,668		

APPENDIX C.—BOXES OF ENGLISH AND SCOTCH SALMON SOLD AT BILLINGSGATE SINCE 1834.‡

	Scotch.	English.		Scotch.	English.
1834	30,650		1860	15,870	438
1835	42,330		1861	12,337	442
1836	24,570		1862	22,796	454
1837	32,300		1863	24,297	663
1838	21,400		1864	72,603	752
1839	16,340		1865	19,009	868
1840	15,160		1866	71,725	1,563
1841	28,500		1867	23,006	2,405
1842	39,417		1868	28,020	1,725
1843	30,300	40	1869	70,474	1,863
1844	28,178	—	1870	20,648	3,120
1845	31,062	46	1871	23,390	2,953
1846	25,510	41	1872	24,404	5,298
1847	20,112	72	1873	30,181	1,471
1848	22,525	48	1874	32,180	1,602
1849	23,690	50	1875	20,375	1,284
1850	13,940	72	1876	25,645	1,508
1851	11,593	40	1877	29,363	1,608
1852	13,044	20	1878	27,660	1,224
1853	19,485	20	1879	15,564	1,898
1854	23,194	128	1880	17,457	2,028
1855	18,197	59	1881	23,905	1,890
1856	15,438	200	1882	22,968	2,186
1857	18,654	220	1883	34,506	2,271
1858	21,564	499	1884	27,219	1,600
1859	15,823	86	1885	30,362	1,897

APPENDIX D.—ENGLAND AND WALES.—NUMBER OF SALMON CAUGHT AS RETURNED TO HOME-OFFICE:—

1867	23,691	1877	174,121
1868	11,358	1878	68,087
1869	24,557	1879	47,234
1870	84,403	1880	56,754
1871	157,060	1881	75,546
1872	153,974	1882	85,797
1873	128,973	1883	90,134
1874	55,080	1884	81,938
1875	60,005	1885	77,707
1876	59,354		

APPENDIX E.—NUMBER OF SALMON TAKEN WITH ROD AND LINE IN ENGLAND AND WALES, AS RETURNED TO HOME-OFFICE.

Year.	Taken.	Anglers.
1867	1,322	795
1868	583	454
1869	973	801
1870	636	442
1871	1,851	1,010
1872	3,518	1,126
1873	4,071	1,245
1874	1,581	1,148
1875	2,026	978
1876	1,532	737
1877	3,091	1,067
1878	1,870	937
1879	7,889	1,615
1880	3,777	1,614
1881	5,913	1,547
1882	5,222	2,011
1883	7,702	2,049
1884	4,069	1,934
1885	7,585	2,224

DISCUSSION.

The CHAIRMAN said there was a slight mistake in the paper which he might correct; a last of herrings at Yarmouth was not 10,000 but 13,200. As to the necessity for the establishment of a Fishery Department for England and Wales, there could be no doubt that the time had come when England ought not to be in the degraded position of having a scattered administration of the fisheries of the United Kingdom instead of a Central Department, and this fact was brought prominently before the public by our Colonial friends at the Conferences held at the Fishery Exhibition in 1883, when it was pointed out that we could no longer stand still as a nation, and that we were bound to take the matter up and place ourselves in the same position as other nations. All the various points urged before the House of Commons had been virtually accepted; the case was so strong that there

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* Scotland only. † Scotland and Isle of Man only. ‡ Each box weighs 112 lbs. on an average.

was no doubt about it; and the President of the Board of Trade accepted the position most gladly. He would not take up time by discussing the necessity for a Fishery Department; that might be taken for granted, but he might mention that the question had been gone into very fully by all the sea fishing interests at the different fishing centres, and also at a very important conference which took place in London when a deputation was introduced to the President of the Board of Trade to discuss the constitution of the proposed Department. It was then urged that there should be some practical element introduced other than red-tape officials by whom they had been encumbered for so many years; the fishing interest were perfectly unanimous upon that point, and he thought Mr. Mundella saw the justice of it, because he alluded to one very important concession as regarded the sea fisheries, viz., that at the larger fishing ports there should be a representative duly elected council, which council should be in direct communication with the Central Department in London, and have power to deal with questions that arose from time to time. When the Bill was introduced into the House of Commons it would no doubt contain among others this power. Whether or not it would be desirable to have a scientific element introduced into the new Department, he would leave to the scientific gentlemen present to discuss, but he would impress upon the meeting that upon this great question, if it was to be carried through the House of Commons, they must not run counter more than could possibly be helped to that important body, the Treasury, because it would be a most unfortunate matter if the ship was water logged, and eventually sunk, in consequence of asking for too much at the commencement. They should first establish the Department on a certain scale, and after it had been established for a few years, they would be in a better position to know whether a further demand should not be made upon the Government of the day to extend the operations in directions beyond those at first contemplated.

Professor Ray Lankester, F.R.S., wished to make a few remarks upon the proper relation of scientific inquiry to any organisation of a Fishery Department. Mr. Willis-Bund had not quite apprehended what scientific inquiry might mean, and what it had done for our industries, though he had admitted it was desirable to have additional knowledge of facts with regard to fishes, in order that satisfactory rules and regulations might be made. But at the same time, while asking for further facts, Mr. Willis-Bund had said that it was not the business of a scientific expert to ascertain facts, and he evidently imagined that a scientific expert was a theorist who weaved a theory upon the facts placed before him. This was not so, it was the lawyer who more usually did that sort of thing. The scientific man was engaged in ascertaining the facts, and when they asked that there should be a scientific element in the Fishery Board, they meant a certain number of officials who would be employed in ascertaining the facts which were admitted on all hands to be necessary to deal satisfactorily with fisheries. If they were to maintain existing regulations, or give advice, or promote schemes with regard to fisheries, it must be done as the result of knowledge. That was the main upshot of the conferences which took place at the Fisheries Exhibition, when the conclusion arrived at was, that more knowledge was needed with regard to the habits, &c., of fishes, in order that satisfactory legislation should be maintained or introduced. The word "science" seemed to be used as a term of reproach, but the real question was whether men shall act in ignorance or with knowledge. Mr. Willis-Bund said that he objected to have fisheries advised upon by scientific experts, which really meant that he would prefer to leave them to ignorance, as it was a mere question between knowledge and ignorance. The point was, whether or not it was desirable that the State should undertake, in connection with a Fishery Department, to ascertain more than was at present known with regard to fishes. In other matters, it had been found that an increase of knowledge had enabled mankind to deal more successfully with natural things, and he had not the least reason to doubt that increased knowledge with regard to fishes would have a beneficial result in the treatment of fisheries. Supposing the point was admitted that, to ascertain the facts which Mr. Willis-Bund wished to see ascertained, persons trained with a certain particular kind of knowledge were necessary, he maintained that further, in order to interpret those facts, and to apply and understand them in a satisfactory way, a certain amount of special knowledge of the subject was desirable. They could hardly have a better instance of this than the one afforded by the reader of the paper with regard to the feeding of herrings, which had been brought forward by him, as proving the untrustworthiness of scientific experts. These two statements were not, as supposed by Mr. Willis-Bund, in any way contradictory, but were perfectly capable of being read and understood in conformity with one another. The first statement was as follows:—"There is a popular belief that the herring does not feed during the spawning season, but this I regard as a mistake, as one always finds a certain per-centage of herrings with food in their stomachs during January and February. This much seems certain, they do not feed so voraciously when the ova and milt are reaching maturity." The other statement was this:—"There is one period in the life of the fish, the so-called matie condition, during which the herring feeds voraciously, grows, and finally lays up a great stock of nutritious matter, while the reproductive organs remains rudimentary." All that was said in the first statement was that the fish did not remain altogether without food during that period. The second statement went on to say, "this is followed by another period during which the fish leaves off feeding, while the reproductive organs attain an enormous size at the expense of the nutritive matter previously stored up in the body," and at first sight no doubt this seemed to be in opposition to the statement that the fish did not feed so voraciously when the ova and milt were reaching maturity, but what the first writer was referring to was the late period of growth and not the early period. The two statements were really in accord, so that it was desirable, in dealing with these facts, that the person should have some knowledge of the subject, and not be liable to fall into error as Mr. Willis-Bund had done. He had himself furnished the best proof of the need for special knowledge. He (Professor Lankester) had always advocated the desirability of the Government providing some means for increasing knowledge with regard to fishes, and had not the least doubt that there was a great deal to be done in this direction. In Italy they had a Fishery Department, which consisted of thirteen members, three being non-scientific, and ten scientific, and the questions submitted to them were submitted through the ministry. The committee met occasionally to consult upon questions, and various members were told off to report upon any particular question, the report being sent up to the whole commission, who either adopted it as a whole, or made certain amendments.

Dr. FRANCIS DAY, referring to the conferences held at the Fisheries Exhibition in 1883, said Sir Edward Birkbeck then stated that the Government first passed Acts with reference to fisheries, and subsequently listened to the complaints of fishermen; that scientific gentlemen gave evidence with reference to the lights of the boats and how they should be carried at night time, and upon investigation it was found that these gentlemen knew nothing of fishing vessels, and had never been on board one for a single night. It was within the knowledge of certain gentlemen that in some of the investigations made into the fisheries, the persons who made the investigations never went to the fishing-grounds, but remained on shore and drew up reports from what they heard from fishermen and people living in the localities. Scientific gentlemen were sent to investigate fisheries at sea, but they remained in a recumbent position while the vessel was at sea, and then issued complicated reports as to what they had seen. The returns which had been issued, showing that the markets were well supplied with fish, were positively misleading. Certain gentlemen said you must not pass laws with reference to fisheries for fear of interfering with the balance of nature, but that was nonsense. The fish which were captured were fish useful for the market, but not the dog-fish and shark, which were useless; so that there was protection for the fish which was useless and destruction to the other, and yet people talked of the "balance of nature." Then they were told that the rules protecting herrings should be taken off, as they were wanted for bait to catch cod-fish, and as cod-fish destroyed herrings, therefore the cod-fish should be destroyed; but the rules for the destruction of fishes were directly opposed to one another. One inspector of fisheries stated at the conferences held at the Exhibition in 1883, that the sea was inexhaustible, and he clenched his argument by saying, "I am sure that the sea is producing the living creatures as abundantly now as when the first book of Genesis was written;" and this was given as an argument for doing nothing Passing to the scientific commissions, he thought it was in the knowledge of most persons that in 1868 a Scientific Commission proposed to do away with all the fishery laws; the opinion of this body was accepted, and for the last fifteen years everyone had been allowed to do as he pleased in fisheries. The gentlemen who formed the commission said:—Let the trawler take all the fish he can, he will decrease the supply till at last it will not pay him to continue fishing, then nature will come to the front, and the fish which remain will replenish the fishing ground, but you should not interfere between nature and man. Fifteen years had elapsed since this new mode of treating the fisheries had been tried, and what did nature now say to the dictum of science? Had soles or flat fish decreased in price? With reference to the composition of the Fishery Board, there were three different classes of persons that might be selected, the man of science, the naturalist and field worker, and the fisherman. The opinion of Professor Huxley, who was considered the head of the scientific men in the country, was that a scientific man should not be at the head of the Department. No doubt scientific men were an exceedingly valuable portion of the community in their proper place, but they seemed to think that they alone were the people to give opinions and facts, and that every one else who did not agree with them was wrong; but what was the position of scientific men in this country? A few years ago they applied to the Government for assistance in carrying out scientific research, and the sum of £4,000 a year was voted, and now they had asked to have a biological station at Plymouth at a cost of £800 a year. What was the result of scientific research in Scotland? At the close of the Fisheries Exhibition in 1882, they asked for, and obtained, the funds which remained over under the promise that they would give reports from seven different gentlemen, but these reports had never been presented. He did not know that the scientific station at Naples had been of much use up to the present, and thought that these stations should be carried out on the inexpensive American plan.

Mr. SAYER regretted that some remarks had not been made upon the practical part of the question, namely, the excessive railway rates for the carriage of fish. Foreigners paid about 10s. a ton, but Scotchmen and Irishmen had to pay £4 a ton. He believed that if they had too much of the scientific element on the Fishery Board it would be the means of destroying one of the chief articles of food. He remembered the time when they could not sell 100 tons of fish in Billingsgate in a day, but now 1,000 tons were readily sold and at a higher price than formerly. At one time plaice and haddock were thrown overboard, as there was not sufficient sale to make it worth while to bring them to market, but now these fish were the main support of many fishermen. What was really wanted was better market accommodation—a retail as well as a wholesale market, so that when there was a glut at Billingsgate the fish might be taken to the retail market and sold at a low price to the poorer classes. London was better supplied with fish than any other town, and the price was 50 to 70 per cent. less than in Paris and 10 to 15 per cent. less than in Birmingham, Liverpool, or Manchester.

Professor MOSELEY, F.R.S., thought the general question was whether matters of scientific importance should be decided by scientific inquiry or not, and in all departments of the Government where science was called in question, the matter had been already decided. Where would commerce be if they had not the Astronomer Royal at the head of the astronomical department; where would our fisheries be if they had what Mr. Willis-Bund seemed to desire, a person to determine on such matters who had no ideas and no theories. If the man was not to be a lawyer, or a man of science, or one who had any theories, what would be the result of his conclusions? He agreed with Professor Lankester that the two statements as to the herring feeding were in no way contradictory, and thought that the reader of the paper did not comprehend or understand scientific statements so as to follow them. He considered that they should follow what had been done by other countries with regard to fisheries, and should, to a certain extent, rely on scientific evidence. The whole thing should not be under a scientific expert, but scientific experts should be responsible for a certain amount of work, and should co-operate with other persons. Notwithstanding the remarks of Dr. Day, he looked forward to a very brilliant future for the Marine Biological Association.

Lord FORTESCUE believed that a great deal had yet to be learnt with regard to salmon and trout, and therefore he agreed with the reader of the paper that it was desirable to have a Fishery Department, and that the sources of information should not be dispersed over various Government departments. If they were to legislate for the conservation or improvement of fish, they must do so from knowledge, or they might unintentionally do unwise things. He believed in the motto of the Royal Agricultural Society, "Practice with science," for there was no contradiction between the practice of science, and no practice could be wise which was based upon ignorance. A man might ignorantly stumble upon a happy practice, but the doctrine of chances were enormously against hitting upon happy results by ignorance. He could not help lamenting that the Government, in a matter of such national importance as fisheries, had not long ago given more assistance to men of science in the researches which were indispensable in arriving at wise and practical legislation. He did not pretend to know anything about it, but he understood that very little was known about the habits of sea fish and their capture. It might be that at present they were too ignorant to legislate usefully upon the subject, but that was the more reason why investigation should be carried on. The constitution of the Italian Fishery Board was one based on very rational principles, as it was composed both of scientific and non-scientific gentlemen. Nothing had struck him more than the wonderful apathy and absence of curiosity on the part of fishermen as to the prey which they were constantly engaged in catching; a large portion of the men never troubled themselves about anything but the most effectual mode of capture, they had no curiosity about the natural history of fishes. He protested most strongly against disparaging remarks as to scientific guidance, and thought that assistance should be given by the Government to accelerate investigation and study, which should form the basis for any future legislation and regulations on the subject.

Mr. CRAMPTON was of opinion that a Board of some kind was necessary, and that there must be sufficient outward pressure to keep it alive. To attempt to carry out the work of such a Board without scientific help would, he thought, be a mere waste of time.

Mr. LIGGINS said that, having paid great attention to this subject for very many years, he had arrived at the conclusion that the scientific gentlemen who lectured upon the matter at the Exhibition in 1883, were thoroughly ignorant upon the subject. The Association at Plymouth was no doubt desirable from a scientific point of view, though he doubted whether anything not already known would be found out. It would be a most impracticable thing to put scientific men on a Fishery Board which was to be managed by practical men for the benefit of their own class and the public at large. Fishermen were not interested in sending diseased fish to market, and the absence of proper laws had been exceedingly detrimental to their interests. He hoped that when the Board was established, it would be composed of practical men.

Mr. WILLIS-BUND, in reply, said he was glad to hear that the idea had been taken up by Mr. Mundella to have a representative council, for unless this were done, the system of fisheries would not be carried out as it ought to be. With regard to the remarks of Professors Lankester and Moseley, he might say that no one felt more strongly than he did the great necessity there was for more knowledge as to the habits of fish, because at the present time nothing was known about them, but he thought the knowledge would be better collected through independent sources than through State-paid officials. He might be wrong, but that was his opinion, and he gave it for what it was worth. As to the person to be at the head of the Board, he should prefer one whose ideas were not purely theoretical but acquired from practical knowledge. Scientific questions of great nicety were decided by laymen and judges in the courts of law after listening to scientific evidence, and a Board of laymen were quite capable of valuing at their true worth the facts brought forward, and therefore he thought that while it was the duty of the expert to collect the facts and put them in such a shape that they could be brought before the Board, it was not the duty of the experts to decide upon those facts. Both Professors Lankester and Moseley seemed to think there was no contradiction between the two statements as to the herrings, and probably there was not; but he did not profess to understand scientific language or theories; he only read the thing as any plain Englishman would read it, and he maintained that if there was any meaning in the English language, the two statements were directly opposed to each other. One said the herring did not feed during the spawning season, and the other said that this was followed by a period during which the fish left off feeding, so that there appeared to be a direct contradiction of facts. Gentlemen who held strong opinions should say what they meant, and not commit themselves to loose statements in contradiction to each other. He hoped that in the future, thanks to Sir Edward Birkbeck, they would have a central Fishery Department which would not only collect scientific information, but endeavour to act upon the information, and promote not only the interests of fishermen but of the public.

On the motion of the CHAIRMAN, a hearty vote of thanks was accorded to Mr. Willis-Bund for his interesting paper, and the meeting adjourned.

Miscellaneous.

COLONIAL AND INDIAN EXHIBITION.

On Wednesday, her Royal Highness the Duchess of Connaught, accompanied by her Royal Highness the Hereditary Grand Duchess of Oldenburg, visited the Exhibition, and was conducted over the various Colonial and Indian Courts by Sir Philip Cunliffe-Owen.

Congratulatory telegrams on the opening of the Exhibition have been received by his Royal Highness the Prince of Wales from the Viceroy of India; from the Governor-General of Canada; from the Governors of New South Wales, Victoria, South Australia, Western Australia, New Zealand, Natal, the Straits Settlements, Hong Kong, and Malta; from the Administrators of Greenland and the Cape of Good Hope; and from the High Commissioner of Cyprus.

The Honourable Graham Berry, Agent-General for Victoria and Executive Commissioner for the colony at the Exhibition, has arrived in London.

The total number of visitors to the Exhibition for the week ending May 8, was 128,077.

ELECTRIC LIGHTING ACT.

The following petition of the Institution of Civil Engineers, against "The Electric Lighting Act, 1882, Amendment (No. 3) Bill," and in favour of "The Electric Lighting Act, 1882, Amendment (No. 1) Bill," was presented to the House of Lords by the Earl of Iddesleigh:—

TO THE RIGHT HONOURABLE THE LORDS SPIRITUAL AND TEMPORAL IN PARLIAMENT ASSEMBLED;

The Humble Petition of the Institution of Civil Engineers, incorporated by Royal Charter "for the general advancement of Mechanical Science and more particularly for promoting the acquisition of that species of knowledge which constitutes the profession of a Civil Engineer, being the art of directing the great sources of power in Nature for the use and convenience of man,"

SHEWETH:—

1. That in the year 1882 an Act of Parliament was passed to apply to all Provisional Orders or Acts relative to the distribution of electricity for lighting and other purposes.

2. By Section 27 of the said Act it was enacted that at the expiration of twenty-one years, or such shorter period as might be provided in the Special Act, and within six months after the expiration of every subsequent period of seven years, or such shorter period as might be provided in the Special Act, any local authority within whose jurisdiction the area of the undertaking, or any part thereof, was situated, might require the undertakers to sell their undertaking, or part thereof, upon the terms of paying the then value of all lands, buildings, works, materials, and plant suitable to and used for the purposes of their undertaking, and in the event of non-agreement the price was to be determined by arbitration; but the arbitrator was forbidden to allow any payment in respect of compulsory purchase, or of good-will, or of any profits which may, or might have been, or be made from the undertaking, or of any similar considerations.

3. That the effect of the foregoing conditions has been entirely to stop, during the four years since the Act has been passed, the application of private capital to the distribution of electricity from a

central station to householders, manufacturers, shopkeepers, and others desirous of receiving it as a source of illumination, it being impossible to find persons of means who would embark their capital in undertakings subjected to such conditions, conditions which must of necessity when enforced—as they would be if the undertaking were prosperous—return to the shareholders only a small portion of the capital which they had invested.

4. That your Petitioners embrace among their members persons practising in every branch of civil engineering, which is defined in their charter to be the art of directing the great sources of power in nature for the use and convenience of man, thus including electrical engineering, and that they are desirous—in the interests of industry and of the growth of a new and useful application of science to the purposes of daily life—that electrical lighting should have a thoroughly full and fair trial.

5. There are now before your Lordships' House three Bills, numbers 1, 2, and 3, each of which purports to be an amendment of "The Electric Lighting Act of 1882."

6. Number 3 Bill, the one brought in by Lord Houghton, does not vary the Act of 1882, except by an extension of the time before the compulsory right of purchase would arise, from the twenty-one years of the Act of 1882 to thirty years, with a further period of twelve years should the local authority agree, and by the extension of the recurrent periods of option from seven years to ten years.

7. Your Petitioners are convinced that such a measure would not cure the defects of the existing law, and would not be successful in attracting capital to an Electric Light undertaking, which must be essentially one of development. Unlike the case of the construction of a railway between two points, of of a canal between two points, or of the making or a dock, cases where the work is done as a whole and where the capital is needed, and is called up at once; an Electric Light undertaking is one wherein, at the outset, only a comparatively small portion of the capital can properly be utilised, and it would not be until after a lapse of years, when persons had been educated to use the electric light, and are willing, for the sake of its advantages, to discard the gas fittings for which they had already paid and to incur the expense of electric light fittings, that there would be such a large or general use of electricity for lighting purposes as to need the expenditure of further capital.

8. That with such a clause as that proposed by No. 3 Bill—a clause which merely defers the time of compulsory purchase—it would be impossible to obtain this extra capital as needed, because even if, at first, persons would subscribe for a probable enjoyment of thirty years, no one would be found to embark money after the lapse of a few years when the term was so much shortened.

9. No. 2 Bill ameliorates Section 27 to some extent, but the Bill (No. 1) now before your Lordships' House proposes to repeal the Act of 1882 altogether, and to assimilate the legislation in respect of Electric Light undertakings to that legislation which of late years has prevailed in respect of gas undertakings, and has proved so beneficial to the public, while yielding security of property to those who embark their capital. Bill No. 1 provides that the obligations upon the distributors of electricity shall be the same as those which are imposed upon gas undertakings, that dividends shall be regulated upon the sliding scale, by which there is a direct incentive to the undertakers to sell the commodity at the lowest possible price consistent with a profit, and, further, that all future capital shall be issued under an auction clause, thus ensuring that the consumers shall not be liable to pay any greater amount as dividend than is fairly demanded by the risk of the undertaking.

10. Your Petitioners desire to point out that the new industry of electric lighting has been, by the Act of 1882, and would, by the Amended Bill, No. 3, if it were passed into law, be subject to burdens which render it impossible to give a mode of lighting that has so much to commend it a fair chance of development, and therefore prevent the establishment of an industry that would give householders and others an option as to the mode of lighting from an external source of supply, an option they do not now possess.

Your Petitioners therefore humbly pray your Lordships that the said Electric Lighting Act (1882 Amendment (No. 3) Bill may not be allowed to pass into law, but that the Electric Lighting Act (1882) Amendment (No. 1) Bill may pass into law, and that this Petition may be referred to the Committee of your Right Honourable House, to whom those Bills have been referred, or that such other relief may be given to your Petitioners on the premises as your Lordships shall deem meet.

And your Petitioners will ever pray, &c.

Sealed with the Seal of the Institution
of Civil Engineers, this 29th day
of April, 1886, in the presence of } (L.S.)

(Signed)

James Forrest,
Secretary to the Institution.

MEETINGS OF THE SOCIETY.

Ordinary Meetings.

Wednesday evenings, at Eight o'clock:—

May 19.—"Watchmaking by Machinery." By Prof. Leonard Waldo, D.Sc. of Yale College, U.S. Prof. J. Norman-Lockyer, F.R.S., will preside.

Foreign and Colonial Section.

At Eight o'clock:—

Tuesday, May 25.—"Cyprus since the British Occupation." By G. Gordon Hake. Major-General Sir Robert Biddulph, K.C.M.G., C.B., will preside.

INDIAN SECTION.

Friday evenings, at Eight o'clock :—

MAY 21.—"Everyday Life of Indian Women." By Capt. RICHARD CARNAC TEMPLE. JAMES GIBBS, C.I.E., will preside.

CANTOR LECTURES.

The Sixth Course will be on "Animal Mechanics." By B. W. RICHARDSON, M.A., M.D., F.R.S.

Lecture III.—May 17.—Some details of results of construction.

Lecture IV.—May 24.—Some special Mechanisms.

Lecture V.—May 31.—Mechanisms continued; and Review in regard to practical applications.

ADDITIONAL LECTURES.

The course of Elementary Lectures on "Electricity" will be continued by Professor GEORGE FORBES, on Saturday afternoons, at Three o'clock :—

Lecture V.—May 15.—Induction.

Lecture VI.—May 22.—Electrical Measurement.

The third and last lecture of the course on "Japanese Art Work" will be delivered by ERNEST HART, on Tuesday evening, May 18, at Eight o'clock :—

LECTURE III.

PICTORIAL ARTS OF JAPAN.—The Buddhist school—Kanaoka and Chodensu, 9th to 15th century—The Tosa school — Mitsunobo — The Sesshiu school, Doan, 15th and 16th century—Chinese school, Shiubun and Sôtan, 15th century—The Kano school, Masanobu Motonobu and Tanyu, 15th to 17th centuries—Old popular school—Matahei and his followers, 16th to 18th century—Korin and Kenzan school, 17th century—Naturalistic school of Okio, 18th century—Colour prints of the Katsugawa school—Hokusai and his pupils.

MEETINGS FOR THE ENSUING WEEK.

MONDAY, MAY 17...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. (Cantor Lectures.) Dr. Richardson, "Animal Mechanics." (Lecture III.)

British Architects, 9, Conduit-street, W., 8 p.m.

Asiatic, 22, Albemarle-street, W., 4 p.m. Annual Meeting.

Victoria Institute, 7, Adelphi-terrace, W.C., 8 p m.

TUESDAY, MAY 18...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. (Special Lecture.) Mr. Ernest Hart, "Japanese Art Work." (Lecture III.)

Royal Institution, Albemarle-street, W., 3 p.m. Prof. A. Gamgee, "The Function of Circulation."

Civil Engineers, 25, Great George-street, S.W., 8 p.m. Mr. William W. Hulse, "Modern Machine-Tools and Workshop-Appliances, for the Treatment of Heavy Forgings and Castings."

Statistical, School of Mines, Jermyn-street, S.W., 7.45. Mr. Charles Booth, "Occupations of the United Kingdom, 1801—1881."

Pathological, 53, Berners-street, Oxford-street, W., 8½ p.m.

Zoological, 11, Hanover-square, W., 8½ p.m. 1. Dr. A. B. Meyer, "A Male Specimen of *Rhipidornis gughelmi-tertii.*" 2. Mr. Frank E. Beddard, "Descriptions of new or little-known Earthworms, together with an Account of certain Structural Variations exhibited in *Perionyx excavatus.*" 3. Mr. Sclater, "Remarks on the Species of Wild Goats, and their Distribution."

WEDNESDAY, MAY 19...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. Prof. Leonard Waldo, "Watchmaking by Machinery."

Meteorological, 25, Great George-street, S.W., 7 p.m. 1. Mr. Charles Harding, "The Severe Weather of the past Winter, 1885-6." 2. Mr. Louis M. Casella, "Description of an Altazimuth for Recording the Verticle Angle as well as the Horizontal Direction and Force of the Wind." 3. Mr. William Marriott, "Earth Temperatures, 1881-85." 4. Mr. Arthur W. Clayden, "Note on the After-Glows of 1883-84."

Pharmaceutical, 17, Bloomsbury-square, W.C., 8 p.m. Annual Meeting.

Patent Agents, 55, Chancery-lane, W.C., 3 p.m. 1. Annual General Meeting. 2. Discussion on Mr. O. Imray's paper, "Suggestions as to the Maintenance of Permanent Offices and a Library for the Institute."

Archæological Association, 32, Sackville-street, W., 8 p.m. 1. Mr. W. de Gray Birch, "The Sculptured Slabs in Chichester Cathedral." 2. Mr. E. P. Loftus Brock, "The Prehistoric Ship Discovered at Brigg." Mr. Richard Howlett, "The Asserted Destruction of Ancient MSS."

THURSDAY, MAY 20...Association for Promoting State-aided Emigration (at the HOUSE OF THE SOCIETY OF ARTS), 3 p.m.

Royal, Burlington-house, W., 4½ p.m.

Antiquaries, Burlington-house, W., 8½ p.m.

Chemical, Burlington-house, W., 8 p.m.

Society for the Encouragement of Fine Arts, 9, Conduit-street, W., 8 p.m. Mr. G. A. Storey, "The Meissoniers at Hertford-house."

Royal Institution, Albemarle-street, W., 8 p.m. Prof. Dewar, "The Alkaloids."

Historical, 11, Chandos-street, W. 8½ p.m. Rev. W. Cunningham, "The Formation and Decay of Craft Gilds."

Nnmismatic, 4, St. Martin's-place, W.C., 7 p.m.

FRIDAY, MAY 21 ... SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p m. (Indian Section.) Capt. Richard Carnac Temple, "Everyday Life of Indian Women."

United Service Institute, Whitehall-yard, S.W., 3 p.m. Rear-Admiral W. Arthur, "The Defence of the Coast and Harbours of England, Ireland, and Scotland in case of War."

Royal Institution, Albemarle-street, W., 8 p.m. Weekly Meeting, 9 p.m. Sir John Lubbock, "The Forms of Seedlings ; the causes to which they are due."

Philological, University College, W.C., 8 p.m. Anniversary. President's Annual Address by the Rev Prof. Skeat.

SATURDAY, MAY 21...SOCIETY OF ARTS, John-street, Adelphi, W.C., 3 p.m. (Special Lecture.) Prof. George Forbes, "Electricity." (Lecture VI.)

Physical Science Schools, South Kensington, S.W., 3 p.m.

Botanic, Inner Circle, Regent's-park, N.W., 3¾ p.m.

Royal Institution, Albemarle-street, W., 3 p.m. Prof. Ernest Pauer, "How to Form a Judgment on Musical Works." (Lecture III.) With Musical Illustrations.

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FRIDAY, MAY 21, 1886.

All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

NOTICES.

CONVERSAZIONE.

The Society of Arts Conversazione will be held, by permission of the Royal Commission, at the Colonial and Indian Exhibition, South Kensington, on Friday, the 16th of July next.

Each member will receive a card for himself, which will not be transferable, and a card for a lady. In addition to this, cards will be sold to members of the Society, or to persons introduced by a member, at the following prices :—Until the 3rd of July, 7s. each ; after that date 10s. each, except on the 16th July, when the price will be 15s.

The Council, however, reserve the right of stopping the sale of tickets or of raising the price, if it is found necessary, in order to restrict the number of visitors within reasonable limits.

Tickets will only be supplied to persons presenting members' vouchers (forms of which can be obtained from the Secretary), or a letter of introduction from a member.

Members can purchase these additional tickets by personal application, or by letter addressed to the Secretary. In all cases of application by letter, a remittance must be enclosed. Each ticket will admit one person, either lady or gentleman.

Light refreshments (tea, coffee, ices, &c.) will be supplied at the usual buffets. No refreshments can be obtained by purchase. It will greatly facilitate the arrangements if members requiring additional tickets will apply for them at as early a date as convenient. The members' invitations will be issued early in June. Visitors' tickets can be purchased from the present date.

There will be no admission to the Exhibition on this evening except by special ticket, and no tickets can be purchased at the Exhibition.

Further particulars as to the arrangements will be announced in future numbers of the *Journal*.

ORDINARY MEETINGS.

The Council have decided (in consequence of Mr. W. Anderson's absence in St. Petersburgh) to postpone till next Session the reading of his paper on "The Purification of Water, &c.," announced for Wednesday next. There will, therefore, be no meeting of the Society that evening. The next meeting for the election of members will be the Annual General Meeting on the 30th June.

ADDITIONAL LECTURES.

Professor GEORGE FORBES delivered the fifth lecture of his course of elementary lectures on "Electricity" on Saturday afternoon, 15th inst., the particular subject of the lecture being Induction. The sixth and last lecture on the practical applications of electricity will be given on Saturday afternoon, May 22nd.

The third and last lecture of the course on "Japanese Art Work" was delivered by Mr. ERNEST HART on Tuesday evening, 18th inst. The lecturer described the Pictorial Arts of Japan, and illustrated his subject by a large number of pictures by Japanese artists, which were hung on the walls.

A vote of thanks was accorded to the lecturer on the motion of the Chairman (Mr. Hyde Clarke).

The lectures will be printed in the *Journal* during the summer recess.

JAPANESE EXHIBITION.

The Exhibition of Works of Art by the great Japanese masters, lent by Mr. Ernest Hart, will close at 2 p.m. on Saturday, 22nd inst.

Copies of the catalogue can be had by members on application to the Secretary.

APPLIED CHEMISTRY & PHYSICS SECTION.

Thursday, May 13, 1886; Professor JAMES DEWAR, M.A., F.R.S., Vice-President of the Society, in the chair.

The paper read was "The Scientific Development of the Coal Tar Colour Industry," by Prof. R. MELDOLA, F.C.S.

The report of the meeting will be published in the next number of the *Journal*.

Proceedings of the Society.

TWENTY-SECOND ORDINARY MEETING.

Wednesday, May 19, 1886; Professor J. Norman Lockyer, F.R.S., F.R.A.S., in the chair.

The following candidates were proposed for election as a member of the Society:—

Armstrong, John, Mansion-house-chambers, E.C.
Gwyther, William Warlow, 43, Lincoln's-inn-fields, W.C., and Reform Club, S.W.
Hollick, Thomas Pratt, 26, Shore-road, Hackney, E., and Regent's Canal Dock, 602, Commercial-road East, E.
Matthey, Edward, 78, Hatton-garden, E.C.
Smith, Dr. L. L., Victoria Commission, Colonial and Indian Exhibition, South Kensington, S.W.
Vickery, George, 18, Addle-street, E.C.

The following candidates were balloted for and duly elected members of the Society:—

Faren, D. S. M., 47, Holborn-viaduct, E.C.
Gatty, Charles T., 43, Grosvenor-road, S.W.
Harrison, Albert, Thames Sugar Refinery, Silvertown, E.
Hodgkinson, W. R., 29, Pembroke-square, W.
Morris, James Archibald, 16, Adamson-road, South Hampstead, N.W.
Newton, Arthur Henry, Belsize Court, Hampstead, N.W.
Newton, John, Park-green, Macclesfield.
Owen, Richard George, 40, Warwick-road, South Kensington, S.W.
Rathbone, Frederick, Ryssel, Rydal-road, Streatham, S.W.
Wimshurst, James, 4. The Grove, Clapham-common, S.W.

The paper read was—

THE MECHANICAL ART OF AMERICAN WATCHMAKING.

By Dr. Leonard Waldo,
Of the Yale Observatory, New Haven, U.S A.

The study of the evolution of a mechanical art in any country is a study in social and political as well as in mechanical science. It often depends for its rapid and progressive growth on the characteristics of the people among whom it is planted. Of no art is this principle more true than of the art of machine watch and clockmaking in the United States. Born among a people who from the beginning of their history had to construct their own devices and machines of all kinds, it has had the same growth and individuality which characterises the manufacture of locomotives, agricultural implements, or house fittings and decorations. Unlike these classes of manufacture, however, and more analogous to the production of firearms, the clock and watch products are suited to other people and other countries. It is the economic question growing out of these facts which has led to my appearance before you this evening, in the somewhat unique position of a visitor from the United States, explaining to an English audience the conditions of growth in a great industry, in the early development of which England for many years maintained the leading position.

One of the sayings which we hear more frequently in England than in the United States, is that the preliminary training for a great President is to be found in rail-splitting or on the towpath of a canal. The truth underlying this homely remark is, that in the United States the freedom from supervision, the assumption of tasks, the absence of help, the necessity for doing things as quickly as possible, the great variety of work which comes to the American boy early, gives him practice in solving new problems without considering precedents. He is obliged to face new difficulties constantly, and he has no one to appeal to for help.

Throughout the country I think you will often be struck with the general mechanical intelligence of artisans. The plumber is pretty apt to know something of carpentry and metal work; the metal worker can paint, or turn from iron to brass. The lines of caste in the mechanical arts are so loosely drawn, that the artisan of one trade is often found, in dull time, at a "job" in quite another department of labour. This versatility is a characteristic of the native American; it is less true of the Irish or the German emigrant who settles amongst us. The presence of this pure American type, the abundant use of water power, the impossibility of competition in agriculture with the other sections of the United States, early led to the seclusion of New England as the manufacturing district. The phrase "as inventive as a Connecticut Yankee" came from the fact that in Connecticut and the rest of New England the artisan class grew rapidly in numbers, and protected by wise legislation in regard to the patenting of inventions, every artisan feels there is a possible road to wealth in perfecting the tools he is working with, or the method of production of the thing he is working at. At any rate, patents are cheap and quickly obtained; he will take the risk, he thinks, and work in his own line to better his condition. He constantly sees his fellows transferred from the ranks of workmen to that of employer and manufacturer, and the result is that he cares little for trade practices, for custom, for what is old; he is only anxious to improve the present modes, to attain his own success.

It was a mind of this type which showed itself in the son of a shoemaker (who was also colonel in the State Militia) in the little town of Brunswick, Maine. Born in 1812, Mr. Aaron L. Dennison had the training which might be characterised as presidential, for he carried a mason's hod at the age of ten, and changed his occupation to that of caring for a herd of cows at eleven. At thirteen he found himself sawing wood and strengthening his constitution for the cares of later life, and a year or so later he was promoted to that position from which so many bright ideas in life have come, the shoemaker's bench. At eighteen his dissatisfaction with this bench led him to take to another, and we find him apprenticed to a clock and watchmaking firm in his native town, where he stayed till he was of age. He left the town of his birth in 1833 to perfect himself as a journeyman watch and clockmaker, going to Boston, where were then good facilities for learning the higher branches of the horological art. His thoughts soon turned upon the organisation of labour in the production of watches looked at as machines for time-keeping, and independent of a value as articles of jewellery or art. It is to be borne in mind that from the beginning of the horological art it had been associated with the workers in the precious metals. The promptness of the driving business life throughout the civilized world was but beginning to be felt in its modern force. Few people cared for the minutes of time in domestic timepieces, still fewer for the seconds. The modern ideas were undeveloped, of synchronised clocks, of observatory time-signals, of swift trains, of banking hours, and stock exchanges in which seconds were of high financial value, of thousands of miles of telegraph wire in the same clock electric circuits once or twice every day, so that Greenwich or Washington time might be furnished with unerring exactitude to railroad superintendent or guard alike. The great public yet were unfamiliar with modern business competition and consequent necessity for extreme uniformity of time in engagements, which is an unconscious accompaniment of the life of to-day. But it was all dawning, and to the mind of Dennison it seemed that timepieces should be made simple in pattern, alike in parts, so that pocket watches could be made in enormous numbers, on principles analogous to those in the manufacture of firearms. The idea haunted him. He writes:—

> "The principal thinking up of the matter was done when I was in business at the corner of Bromfield and Washington-streets, Boston; and many a night, after I had done a good day's work at the store and a good evening's work at home in repairing watches for personal friends, I used to stroll out upon the common and give my mind full play upon this project. And now as far as I can recollect what my plans then were as to system and methods to be employed, they were identical with those in existence at the principal watch factories at the present time."

In 1840, Mr. Dennison predicted "that within twenty years the manufacture of watches would be reduced to a system as perfect and expeditious as the manufacture of firearms at the Springfield armoury." Capital was not forthcoming, however, to what seemed a visionary scheme. It was not until 1849, when a friend, Mr. Edward Howard, approached him for his advice as to the expediency of setting up works for the manufacture of American locomotives, that he had the opportunity of suggesting the probable paying qualities of an establishment for making watches as other machinery was made with interchangeable parts, in large quantities, and with the principles of shop management of mechanicians rather than of the watchmakers. This proposal impressed Mr. Howard more favourably than his own plan for building locomotives. Together they found a capitalist willing to share with them the risks of the adventure. I shall use Mr. Dennison's own words as to what followed the meeting of the three projectors:—

> "I suggested that the first money spent in the undertaking should be for a tour of observation in the watchmaking districts in England, with the view of ascertaining whether the trade of watchmaking was carried on there on the system represented to me by English workmen I had employed from time to time in repairing. Another object I had in view was to find out the source of supply for the necessary materials, such as enamel for dials, jewels, &c."

Then he goes to England on the proposed mission, and writes, in regard to it:—

"I found that the matter had been correctly represented, but in carrying out their system one-half the truth had not been told. How that the party setting up as manufacturer of watches bought his Lancashire movements—a conglomeration of rough materials—and gave them out to A, B, C, and D, to have them finished; and how A, B, C, and D, gave out the different jobs of pivoting certain wheels of the train to E, certain other parts to F, and the fusee cutting to G. Dial making, jewelling, gilding, motioning, &c., to others, down almost the entire length of the alphabet; and how that taking these various pieces of work to outside work people—who, if sober enough to be at their places, were likely to be engaged on someone's work, who had been ahead of them, and how, under such circumstances, he would take the occasion to drop into a 'pub' to drink and gossip, and, perhaps, unfit himself for work the remainder of the day.

"Finding things in this condition, as a matter of course, my theory of Americans not finding any difficulty in competing with the English, especially if the interchangable system and manufacturing in large quantities was adopted, may be accepted as reasonable."

I cannot omit, in this connection, a reference to the contemporary art of the application of machinery to watchmaking in France as well as to England. By reference to documents, now in the Guildhall Library, of the Clockmakers' Company in London, I find that the Clockmakers' Company opposed the erection of works and the granting of a Charter to a company, known as the "British Watch and Clockmaking Company. (By Royal Letters Patent.) Capital £250,000 in 10,000 shares. Deposit £2 10s. per share." In a report of a committee of the guild, they review the attempts of Mr. Ingold to establish companies for systematising the production of watches and clocks in Paris in 1835, concerning which the committee says:—

"The committee is enabled to state it failed entirely, without realising anything to the parties who embarked their money on the speculation. It was scarcely two years in existence, for early in 1838, Mr. Ingold was in London, endeavouring to open a door to transfer his unsuccessful project to the shoulders of the British public, but the bait at that time was not alluring, and the project for a season abandoned.

"The Parisian Watchmaking Company having expired, a similar company, with similar pretensions, without the name of Mr. Ingold attached to it, made its appearance at Versailles in the year 1838. By some it is denied that Mr. Ingold belonged to this establishment, but it will require more than simple assertion to make such statement credible. The prospectus of this company, issued in 1838, contains the following: Manufacture of French watches, established at Versailles, under the special protection of the king. The manufactory which, from its commencement, has obtained the powerful patronage of the king, has been in full operation since 21st February, 1838. It already employs more than 200 workmen, attracted from the best workshops of France and foreign countries. It is not a matter of speculation—it is a thing accomplished. A board of manufacturers, including the principal watchmakers of Paris, MM. Lepante, Lessine, Charles Leroy, Robin Mathieu, constantly overlooks the perfection of the works.

"The object of the company is to liberate France from the tribute she pays to a foreign country, and to restore to our commerce a part of the thirty millions at least which are drained yearly to buy more than 120,000 watches from Geneva. The company is already in a position to satisfy all orders for watches from 200 to 600 francs; it can multiply the number of its productions by means of the perfect machines which it possesses. By the aid of those machines the principal parts of a watch are made of uniform size and great quickness; the precise exactness is an invaluable advantage, which alone renders the establishment without a rival of its kind.

"A watchmaker who visited this vaunted establishment in 1839, has given the committee the following particulars:—I was introduced into spacious premises; two or three directors received me with much courtesy. I was shown a large room containing machinery for escapement making, &c., but of the two hundred men said to be employed, the number I saw did not exceed six or eight, these were occupied in making watches without the aid of machinery, employing only the tools generally in use. I did not see a single complete watch. The person who introduced me to this establishment called at my house in London in 1840, and told me that it was defunct. It is remarkable that coincident with the periods at which the formidable machinery of these companies ceased to move, Mr. Ingold came to reside in London and renewed his canvass for support to a 'British Watch and Clock Making Company' which, increasing its pretensions, has put forth its title to the trade of the whole world.

"The committee has in vain attempted to discover the names of those 'most experienced makers of watches in London, those men prominent in science, not one of whom has expressed a doubt of the efficacy of the machinery to facilitate the manufacture of watches, or of the fact that work so produced will be incomparably superior to that done in the usual way.' On the contrary, some of our manufacturers and several of our practical and scientific workmen who have seen the machinery, have not only directly denied the possibility of its success, but have rejected advantageous overtures to identify themselves with the company.

"In reference to the objects of the company, and the powers it assumes to possess, the committee, as practical men, nurtured in the watchmaking business, explicitly states its conviction and belief that they are absurdly and fallaciously stated. It has given the company an opportunity to prove before it the powers and applicability of its machines to effect the miracles that have been ascribed to them. At an interview, 22nd March, 1843, on its premises at 75, Dean-street, Soho, they were then requested, urged, and challenged to exhibit proof of the working of their machinery before your committee. The favour was claimed on behalf of the trade at large. This request was refused upon the most frivolous and contradictory pretexts. The committee advisedly declares its firm persuasion that the company is not in a capacity to make good its assertion upon the subject of letters patent which have been taken out to secure these newly-invented machines to the company, the committee would remark that the specifications have not yet been enrolled. It considers the features of the case to present the strongest ground for a petition to Parliament, praying it to refuse its sanction to the doubly concentrated monopoly. The rise and progress of this adventure has been thus far traced, together with the career of its founder; he has failed in carrying out a similar object in Switzerland, in Paris, and in Versailles, and he is now re-asserting the same pretentions, the stale romance of twenty years, upon the credulity of the British public.

"It may be asked, if this undertaking be founded on such a visionary basis, why not leave it unnoticed to fall piecemeal into ruin?

"The reply is evident and conclusive. At the same time that its failure is most confidently predicted, the consequences involved in its destruction are not to be lightly regarded. At a time when the watch trade is languishing in sympathy with every branch of our national industry, the uncontradicted assertions of the company's prospectus have aggravated the depression; and although manufacturers of watches are fearless of competition, and regard as impracticable the success of the company, yet they cannot conceal from themselves the fact that a large capital worked against them, under the protection of monopoly legalised by Act of Parliament, though for a limited period, may severely prejudice their interests, and involve a large body of industrious workmen in privation and distress."

The Bill for the formation of the English company was thrown out by the House of Commons on the 31st of March, 1843.

It has been stated in English horological circles that Mr. Dennison had the benefit of Mr. Ingold's ideas and inventions in the formation of his own company in the United States. I cannot find any evidence that this is a fact; and in this connection, as a contribution to the history of the early American horology, I will give Mr. Dennison's own statement of his knowledge of Mr. Ingold and his schemes.

"I have to say I never heard of Mr. Ingold or his operations until after our factory was built at Roxbury, and were hiring our workpeople. An applicant for a situation, a Frenchman by the name of Boudet, I hired to do the facing of pinions, as that work required some hand manipulation such as no machine which had been thought of at that time could do it so well—so far as I know, the thing has not yet been accomplished. This man Boudet told me that he was a son-in-law of Mr. Ingold, and, I think it fair to conclude, had worked for him in London; but I have no recollection whether he told me so, or whether he informed me of the connection between himself and Mr. Ingold at the time, or after he had been at work some time. I never saw Mr. Ingold, but I knew of his being about in Switzerland during our residence there. I never knew of his being in America until a long time after we came here (Roxbury) to live. I always had the impression that the British Watch Company obtained an Act, as I was told by Boudet, or some one I thought knew, that it cost, to obtain the Act, £30,000; and that the machine which he got up for making the plates alone cost £6,000."

The first company formed in the United States was not, financially speaking, a success, neither was the second. There had not then been found the financial ability for the head of such a company, and it was not found until May of 1867, when Mr. Royal E. Robbins bought the factory for $56,000—on which Mr. Dennison, his friends and successors, had expended some $250,000—at an auction sale.

It was one of those happy assumptions by a man who had great capacity and a recognised financial ability, of a great manufacturing interest, to which he proposed to bring the new and needed element of business sagacity. It became the precedent for the formation of other companies, and now, instead of the single company at Waltham, there are in the United States its great and well-managed rival company at Elgin, Illinois, and the smaller companies at Rockford, Aurora, Springfield, Ill., and Springfield, Mass., Nashua, N.Y., Columbus, O., Fredonia, N.Y., and Thomaston, Conn., and I am told there are nine others at the present writing in process of organisation. The combined output of these factories, which produce watches of durability and a certain excellence of manufacture, is not far from 4,000 per day, of which the parent company produces about 1,100, with a machine capacity for 500 more per day.

The total population interested in the manufacture and selling of watches and clocks, directly and indirectly, in the United States, is not far from 100,000 people, and the sales of the leading company during the year 1884 amounted to $3,900,000 of products.

To give some idea of the extent of the entire industry in 1880, I quote the following Table, made up from the returns of the United States Census for that year, remarking that the industry has very much increased since that date: —

Table showing the Statistics of Clock and Watchmaking in the United States in 1880.

Subjects.	No. of establishments.	Capital.	Average No of hands employed.			Total paid in wages per year.	Value of materials.	Value of Products.
			Males over 16 years	Females over 16 years	Children or youths.			
		$				$	$	$
Clocks	22	2,474,800	2,807	630	503	1,622,693	1,908,411	4,110,267
Watches	11	4,144,327	2,127	1,219	—	1,712,276	982,224	3,271,241
Watch Cases	27	1,584,740	1,418	139	201	976,041	2,812,922	4,589,314
Watch and Clock Materials	20	117,550	184	45	49	86,050	130,315	300,195
Totals	80	8,321,517	6,536	2,033	753	4,397,060	5,833,872	12,271,020

It is not to my purpose to follow out the actual making of individual watches by machinery; that is quite impossible in an hour's paper. The study of a machine for the automatic manufacture of screws alone could occupy the time. The object is rather to analyse the broad difference in the requirements of the industry when it is transferred from the journeyman's bench to the well-appointed machine shop. I shall draw my illustrations from the great company to which I have already referred, having its location at Waltham, a little town some twenty miles from Boston, in Massachusetts. I do this because this company exhibited a very fine array of its machines at the Inventions Exhibition, and my effort now will be to add to your knowledge there gained, the ideas of policy and management regulating such a great establishment.

A new people is not an art people. It takes age, leisure, and accumulated wealth to give masses of the people artistic ideas. The first test they apply to any new machine is that of utility. In the United States this is a fundamental element of the early success of the watch companies. Automatic machines are very costly. No one can afford to make automatic machines for a thousand watches, or for a hundred thousand. It is only when a simple type can be made and have an enormous sale, that machinery can be extensively applied. In the United States the company of which I speak barely lived until the Civil War broke out. Immediately there was a great demand for watches, strong, serviceable, uniform in quality; there was an opportunity to make a simple type. The buyers were not critical as to finish, if only the watches would run. They did not require art in the case, so long as it was strong. A minute a day was accurate enough for their use, and the art could easily produce such timepieces. There was the opportunity. The factory which paid no dividend at the beginning of the war, paid 4 per cent. the first year, 11 per cent. the second, 22 per cent. the third, and two dividends of 60 and 150 per cent. the last year of the war. It would have been impossible to pay any such dividends except that the watches were of simple types—interchangeable parts—screws, plates, hands, wheels, and dials, all manufactured by machinists, running well-made machines, under the supervision of machinist foremen.

The machinery was built and paid for. The great questions of getting homogeneous raw material, of learning the capacity of machines, of determining what kind of labour—whether of boys or girls, or men or women—was most efficient in any given department, had been settled. Through the simple, cheap, but efficient work of the years from 1857 to 1865, the whole art of machinery, as applied to making watches, was being studied by men of the highest mechanical and business ability, and without the slightest regard to any preconceived trade notions or customs or traditions. The great idea was that millions of now civilised people wanted watches, with China, and Japan, and India and Africa yet to be heard from.

To create and to supply any such possible demand would require the same business organisation as the supply of cottons or metal ware. There must be an organisation reaching from the selection of the raw material to the selling of the product in distant markets. To secure homogeneity of material, *i.e.*, uniform texture of the metals employed, without which machine-made watches would be of temporary value, the most recent advances in physics and chemistry must be made use of. To time the watches properly, not only are the observatory time signals from Harvard University used, but a separate observatory, fitted up with a recording chronograph and transit instrument of a refined construction, has been erected. A dark room, with all the apparatus for experimenting in photographic processes of reproducing dials, &c., is in full operation. Systematic experimenting in tempering steel, in testing metals for their physical properties, is carried on, and some of the most exquisite physical apparatus I have ever seen, I have seen in these measuring-rooms. Those of you who are microscopists, and who know of the extreme accuracy of the small standards of length made by Professor W. A. Rogers, of Harvard University, need only be told that the most beautiful of his smaller machines was built and used at the Waltham Watch Factory, under the combined direction of himself and the mechanical superintendent.

Given a scientific knowledge of the raw materials, a certainty in their selection, and it becomes possible to reproduce the hand processes of manufacturing the small parts of watches by automatic machines. This requires the fundamental department of the company—a well appointed machine shop, in which their machinery can be constructed and repaired. This machine shop occupies the three stories of a wing 150 feet long. The operatives from this department have the constant supervision of the machines, which are systematically arranged along the three and a-half miles of work benches which extend over the nearly five acres of floor space covered by the main buildings. For driving the machinery throughout the factory, a Corliss engine of 125 horse-power works through 39,000 feet of belting, 10,600 feet of main shafting, 8,000 feet of wall rods, and 4,700 pulleys. The number of operations, most of them accomplished by automatic machinery, which is "tended" by a young woman or man having no special knowledge of horology as a whole, in the manufacture of, say, the common "18-size full plate, keyless, four pair jewels" watch movement is, by count of the twenty-five foremen of the different departments in which it is made up, about 3,746.

The American system of manufacturing by interchangeable parts means much more than making a part under the roof of a factory, buying other parts in the market, and obtaining other parts by the piece from workpeople who live in their own cottages, for which they are paid at piecework rates. It means the establishment of working facilities for the entire manufacture. That everything is made on the premises, not according to the plans or ideas or methods of work of individual workmen, but under the direct supervision of a company's foreman, according to gauges the company furnish, under conditions of time, cleanliness, and care which the company prescribe. The operative himself is a machine. There is as little as possible variation in the drill of a great factory.

The results of this are shown in a promptness of delivery, in a uniformity of products, utterly unattainable under the prevalent methods of what is called the factory system outside of the United States, where the work of operatives is collected from their local habitations to be made up into timepieces at a central putting together establishment.

A little later in the evening, we shall see, from the photographs, the various departments of a great watch factory, and I pass now to other considerations of interest to you. It is already apparent to you that the master-mind of such a company is to be chosen for his general executive qualities, and his ability to conduct a manufacturing business, rather than his technical knowledge of watches. In 1884, there were 2,500 operatives in the factory we have quoted. Only a few, and those in the designing and putting together departments were professional horologists. There are machinists, and draughtsmen, and die sinkers, and steel workers and gilders, and enamellers and photographers, and men of many trades, each working in their own departments. Their tools are found by the company, they work on the company's premises, they report at a given hour, have certain intervals for rest, and go home at another hour. They are exposed to the strictest supervision during the progress of their work, and they have every attention given to their personal comfort. Plenty of light, plenty of fresh air, and a comfortable warmth pervades every part of the enormous buildings, to which the 2,500 (in 1884) operatives repair every morning for their duties. Taken all in all, I believe it is the most intelligent body of operatives in any industry known to me. Making up, as they do, the community in a very cultivated part of New England, they have every opportunity in the way of libraries, literary clubs, church life, and social advantages. One is very much impressed with the intelligence, taste, and general attractiveness of the operatives generally, and the women in particular, as they sit at their benches and machines. The delicacy of their work and the *esprit de corps* of the entire body are the two conducing factors to this result. In giving employment, a good character is insisted on. It is rather a remarkable fact that almost the entire number are native born American, with very few, almost none, of the Irish, who are most numerous in other systems of manufacturing. The morality of the young women is on a par with their general intelligence. It is very rarely indeed that one is found against whom the breath of scandal is heard. Marriage amongst the operators is frequent, and the romance of life is not ignored. Homes are made as well as watches. There has grown up in the factory the spirit of interest in its social associations, in its products, and an interest in its reputation, which can only come of a large, industrious, intelligent, well-fed and well-paid community. The company finds it to their interest to maintain these feelings among the operatives. Parks are laid out; cottages, which are both tasteful and healthful, are built; good drainage and ventilation are secured; trees, flowers, lawns are used to beautify the homes, streets, and grounds about the factory buildings. A large hotel has been built for the exclusive use of the young women who are not married, and who wish to live in it. I had the pleasure of dining at this hotel, in the dining-room at the tables of which about 120 young women were seated. The meal was nicely served and consisted of roast beef, roast mutton, potatoes, corn (maize), turnips, with apple pie and coffee and cheese for dessert. The charge which the company makes for board alone is $2 25c. per week, or for board and lodging, $3 per week. Breakfast is served at half-past six in the morning. Now when we consider the average daily pay of the women on the rolls is $7 98c. per week, it can be understood that they have a margin for dress and other things which makes their life quite attractive to them. With their general intelligence there is born the natural desire to become skilful and expeditious in their work. They become specialists with the new machines put into their hands. They know machinery to be their friend, for anything which will make two watches where one was made before, will halve the cost of the watch, but will not halve their wages, and will make their services still more valuable to the company. They are not afflicted with trade notions or customs; they are thoroughly malleable in their methods of work, and quick to do any new thing required of them. They are inventive and suggestive.

Under the administration of such great establishments, there have grown up completely new methods of work. The claim that the machinery, processes, methods of organisation of a great American watch or clock company are not original, is as ridiculous is to say that the Falls of Niagara are not original. The one is as much a product of the inventive genius, the disregard of trade laws and customs, the intelligence and necessity of production of an Anglo-Saxon country separated by 3,000 miles of water from any other Anglo-Saxon country, as the Falls of Niagara are the product of the waters of the lake basin, and the topography of its outlet. The machines of these places are unique. They must be so. They are made on the premises to suit the individual needs of the establishment. For some of the important processes there are as many kinds of machines as there are distinct factories in the United States.

So far we have been referring to the middle class of watches, made in lots of many thousand at a time, and designed for general use. But it is evident that it needs only the addition of the adjuster's skill to produce on the same system, timepieces of a very high precision of running. So the leading American watch companies have put forward the claim that it is only necessary for them to add an adjusting department to their factory organisation, and they will produce timepieces which will be much less in price, and equal in performance to the timepieces made by the very best foreign producers on the old systems. So such adjusting departments have been added to several of the leading factories. In these departments a watch is rated and adjusted to position and temperature for periods ranging from a week to six months, depending on the price at which the movement is to be sold. The watches which are meant for the very finest time-keeping are adjusted at two extreme temperatures, and in the fine positions of dial up, dial down, pendant up, pendant right, and pendant left. The adjustment of a watch is somewhat analogous to the adjustment of sights on a rifle. All the parts of an admirable weapon may be there, and the sights may be approximately right; but it takes actual trial, and the slight adjustment of the sights, to make any given rifle do its most accurate work.

As far as the success attained by the American method in watches of the very highest class is concerned, I can do no better than to quote the results of the trials of timepieces at the Observatory in Yale College, made under the direction of the Corporation of the College for the years 1881 and 1884 inclusive. Their trials are conducted at the Observatory of Yale College, and involve the daily comparison of watches in the following positions and temperatures, for a total period varying from six weeks for watches of the highest class, down to twelve days for watches of simpler adjustment, according to the following schedule:—

Test No.	Position.	Approximate Temperature.	Number of days trial for Class Certificates.			
			I.	II.	III.	IV.
1	Dial vertical, Pendant up	60° to 70° F.	7	8	8	12
2	Dial vertical, Pendant right	60° to 70° F.	2	2	—	—
3	Dial vertical, Pendant left	60° to 70° F.	2	2	—	—
4	Dial horizontal, Dial down	50° to 70° F.	2	—	—	—
5	Dial horizontal, Dial up	60° to 70° F.	10	8	8	or 12
6	Dial horizontal, Dial up	34° to 38°	1	1	1	—
7	Dial horizontal, Dial up	95° to 100°	1	1	1	—
8	Dial horizontal, Dial up	60° to 70°	10	—	—	—
9	Dial vertical, Pendant up	60° to 70°	7	—	—	—
	Total number of days	..	42	22	18	12

The conditions excluding watches from receiving certificates of any class were as follows:—

1. When the variation of rate with the dial vertical and pendant up in classes I., II., III., and in the positions indicated in class IV., exceeds $2^{s}.0$ from one day to the following day.

2. When the variation of rate between the positions of "dial up" and "dial vertical" exceeds $10^{s}.0$.

3. When the variation for 1° F. exceeds $0^{s}.3$ between the ordinary temperature and the oven.

4. When the rate is greater than $10^{s}.0$ per day in any position.

The number of watches entered for the period under consideration was as follows:—

1880-81	219
1881-82	53
1882-83	41
1883 84	87

and the analysis of the results of watches of the highest class for the four years, is as follows:—

	1880-81.	1881-82.	1882-83.	1883-84.
Per-centage of watch movements receiving certificates of any kind, excluding watches entered for rate records	45	38	28	77
Number receiving Class I. certificates ..	22	12	8	42
Average mark of Class I. certificates ..	68·8	68 6	76·4	74·4
Average mark of the first five watches receiving Class I. certificates	79·4	77·0	80·4	85·8
Highest mark received during the year	83	82	85	90·4
Makers' name of watches receiving the highest mark during the year	American Watch Co. Waltham.	Barraud & Lunds, London.	Vacheron & Constantin, Geneva.	American Watch Co., Waltham.

In reference to these "marks" I would like to explain that they are affixed to certificates on a scale of 100, of which 40 are awarded for a perfect position adjustment, 40 for the capacity of a watch to run at a uniform rate from day to day in any given position, and 20 for a capacity to run without a change owing to ordinary changes of temperature. The Table shows, therefore, that in two of the four years' trials one of the American companies entered watches which were the very best in performance of all the watches entered, and that the watch showing the highest record of any entered, was one of American manufacture. I quote these results as conclusive evidence that by the American system of machine watchmaking, watches may be, and are produced, having all the fine running qualities of the best watches made under the ordinary system at a much greater cost.

[At the end of the paper a series of views of the buildings at Waltham, illustrating the various processes of manufacture and the social life among the operatives, were shown on the screen by means of the electric light. A watch movement, made at the factory, was also shown in motion on the screen, to illustrate the detailed parts of a movement as made by machinery.]

DISCUSSION.

Mr. **Whipple** said, that having had an opportunity of testing some of the watches made at the Waltham factory, he could bear out the statement as to their excellent going qualities. The scheme for giving marks indicating the value of watches as timekeepers was the same at Kew as at Yale, and he had to thank Dr. Waldo for the great assistance which he had rendered in the elaboration of the present system. He believed the system was very closely analogous to that which had been employed for many years at Geneva, with one exception, viz., that at Geneva and Neuchâtel monetary prizes were awarded for watches which obtained the highest number of marks. In England, watchmakers had become alive to the necessity of improving the manufacture, and they had come to the conclusion that there was some little good in rating watches and having them certified, though at the outset they ridiculed the idea. He knew of an instance where a customer had been told that a Kew certificate was worth nothing at all, as it did not mean the watch would go well; but upon the customer pressing for a certified watch, he found that the certificate added fifty per cent. to the value. Another difference between the Yale and Kew rating in the adjudication of marks, was that at Geneva a greater proportion of marks were given to accurate compensation. Dr. Waldo and several horologists had given it as their opinion that the attainment of practically correct temperature compensation was comparatively easier than the attainment of correct rating in position, and his experience tended in great measure to confirm this. Many more watches failed to obtain certificates on account of their not going correctly in varying positions than on account of variation in temperature; and the art and mystery of compensating for temperature appeared to be very well mastered by the makers who sent their watches to Kew to be certified. With regard to making watches by machinery, he might mention that this was now done at Coventry, though whether successful from a financial point of view he was unable to say. He had been told by one of the managers that in one wing of the factory watches were being made by hand, and in another by machinery, with a view to a comparison being made of the relative cost of production by hand and machinery. Many parts of a watch must of necessity be better made by machinery than by hand; but other parts, such as screws, could be turned out at less cost by hand by the operatives, as the number required was not sufficient to pay for machinery. As the escapement wheel required to be made to the greatest nicety, it could in all probability be made much better and more cheaply by machinery than by hand. Considering the large number of persons of the lower classes who were out of employment, and whose services could be obtained at a cheap rate, he doubted whether it would be a profitable speculation to erect machinery in England for turning out screws.

Mr. H. GANNEY, speaking as a practical watchmaker who had been at the Waltham factory eighteen years ago, and as one who had written and lectured on the subject, said he hoped the outcome of the reading of this paper would be something practical for the art in general, and also to watchmakers in particular. No doubt England had lost a good trade, and for this they had to thank the British Parliament, which, in 1843, refused to grant a charter to a company for the manufacture of watches by machinery. Ingold, to whom reference had been made in the paper, after passing his time between England, America, and Switzerland, died almost unknown, but one of his machines was still to be seen at the factory of Messrs Gillett and Bland, at Croydon. Watches were now made in London by Mr. Nicholl, by means of machinery, and also by Mr. Gee, who employed over 200 men, and it would be many years before the Americans would be able to turn out watches to equal these. There were two ways of looking at a watch, first, as a work of art, and next, as a piece of commerce, and his own opinion was that they had not yet seen all that could be done in this direction. However great the success of the American companies, they had not yet surpassed the watchmakers horologically. Neither did they put such beautiful work into their watches as would be found in an English watch. He could not agree with Mr. Whipple that it would not pay to make screws by machinery on a large scale if you only wanted a few at a time, because he knew as a matter of fact that it did pay. On behalf of the Clerkenwell watchmakers, he acknowledged that they were under great obligation to the Waltham Company for what they had taught them, and thought that if they were sensible they would take the lesson to heart and endeavour to beat the company.

Mr. BEDFORD begged to call attention to the fact that, in speaking of the factory at Waltham, Mr Ganney was speaking of what he knew eighteen years ago. Of course, in the present age, eighteen years was almost like a century, as things changed so rapidly. The factory and machinery which was there eighteen years ago was now all gone.

Mr. GANNEY said that Mr. Dennison, of the Waltham factory, was now in Birmingham, and had been there eighteen years, and he established a factory in England sixteen years ago.

Mr. ROBERT BRAGGE (Secretary of the English Watch Company) was extremely gratified to find that thanks were given to those to whom they were due, and that at last the labours of Mr. Dennison had been acknowledged. The reasons given by Dr. Waldo for the enormous strides that machine watchmaking was making in America was the true one, that the people there found themselves face to face with necessity, besides being unencumbered by tradition. It was a new field, and they entered upon it and went ahead; but in England they were not so happily placed. If there was one disadvantage under which workmen were placed, it was that of holding too much to tradition, from which it was extremely difficult to emancipate them. They made watches as they did for the same reason that the Dutch built their boats, viz., because their grandfathers had done so before them. In Birmingham, there was a factory which turned out a considerable number of watches by machinery; and it was only by the application of machinery, and following on the lines that had been indicated that evening, that watchmaking could hold its own in England. The company with which he was connected had sent a good many workpeople to America, but, up to the present, they had not had the chance of sending any watches, owing to the heavy import duty; but he had no doubt that by and by they would be able to do even this. In conclusion, he begged to offer his tribute of admiration for the extremely fair and candid spirit displayed in this paper, and hoped that it would spur Englishmen up to a spirit of emulation, and lead them to achieve similar feats to those which had been accomplished in America.

Mr. G. WILLIAM FRODSHAM (Parkinson and Frodsham) thought that the thanks of all watchmakers were due to Dr. Waldo for having given them such a clear insight into the industry of watchmaking by machinery in America; but the system was not quite unknown to English manufacturers. He had just made the model of a machine for making ordinary watches, which he intended to take out a patent for in America as well as in England. When American watches were first introduced into England, he made the remark that he was very glad the Americans were undertaking to supply the millions, because it would give English makers time to devote to the manufacture for the hundreds, that was to say, the aristocratic watches, and he saw no reason now to depart from this view. Reference had been made to an English company which did not succeed in consequence of the opposition of Parliament; but this was, no doubt, owing to the fact that in those days there was a strong prejudice, more particularly on the part of workmen, against the introduction of the machines designed by Mr. Ingold, so much so that at one time this gentleman went in fear of his life, and no doubt the views entertained by the watchmakers and workmen influenced members of Parliament, who, of course, had no technical views upon the subject.

Mr. LIGGINS said that for a large number of years the English public had not been able to get a well-made, good English watch, except at a high price, and therefore, it was time that English manufacturers began to bestir themselves. No doubt many would recollect that some forty or fifty years ago a public company was attempted to be got up for the manufacture of watches by machinery by Mr. Barwise, of St. Martin's-lane, but it was found impossible to work the company owing to its being opposed tooth and nail by watchmakers and working men. He had not seen a watch factory in the United States, though he had in other countries, and he could bear testimony to the correctness of the statements made with regard to them. He considered it a dire misfortune for the English public and the trade of the country that the export in watches was falling off. As a rule he did not think this applied to high-class watches, for it was generally found that when a colonist visited this country he took back with him a first-class English watch; it was the trade in cheap watches that was being lost. For rough usage a machine-made watch had many advantages over a hand-made watch, price and quality being considered.

Mr. GLASGOW thought that a good many of the remarks which had been made that evening had been of a personal nature, and not in elucidation of the paper. Dr. Waldo had read a paper which had been highly appreciated, in which he had not introduced any controversial subjects. Having done the Horological Institute the honour of calling upon them the previous evening, he said, "This is what we want in America," which he (Mr. Glasgow) took as a compliment to England. It was supposed by some people that watches were all made by hand, but this was a fallacy, there not having been a watch made entirely by hand for centuries. The question to be considered was, how far could machinery be adopted with advantage to the great watchmaking community of the country. If there had been as many watchmakers in the United States as there were persons in that room, watchmaking by machinery would not have existed; it was the necessity that caused it. On behalf of the watchmakers in general, he expressed his gratitude to Dr. Waldo for his interesting paper. There was one remark in the paper with which he could not quite agree, viz., that the workpeople were "machines." Was it by machines that watchmaking had been brought to its present state of perfection? Were the great watchmakers of France "machines?" If so, watchmaking would not be what it was at present. They must not conclude that because the cheap grade of watch was made by machinery, that machinery would do everything. He believed that watchmakers were very much pleased when the system of testing watches at Kew was first established; but there was one practice which they did not appreciate, and that was this, that when a man made a first-class watch, and received a certificate for it, the certificate could be changed to any other person on the payment of 1s. This practice he thought was not conducive to the interests of watchmaking.

Dr. WALDO did not believe there was anyone who had been a student of theoretical horology who had a higher appreciation than himself of the genius of the distinguished men to be found in the list of British horologists. There was no finer record to be found than the names of Harrison, Earnshaw, Reid, Dent, Frodsham, and others, but he had not intended to present the scientific side of horology; it was merely the great art of making timepieces for a gradually growing civilisation over the large world that he came to speak about. That was the question to be considered, and not the question of absolute science of precision in timepieces. The question which the Americans were facing was that of making watches which should keep time at the lowest possible price. He did not know that there were any questions which required an answer at his hands, and he would conclude by thanking the meeting for the kind way in which it had received him.

The CHAIRMAN, in proposing a vote of thanks to the reader of the paper, referred to the extreme interest of the subject, and the admirable way in which that interest along many lines had been developed. The question of the watch was really one of national importance, and there were even interesting side issues which almost rose to the height of political economy, in connection with the manufacture of such an article under new conditions, as opposed to its manufacture under old conditions. It was clear that the sense of the meeting was that England did lose once upon a time a very fine opportunity of expanding the watch trade, when the indications of science were pointed out a good many years ago. He thought that was not only true of the watch trade and of England, but it practically must be true of all trades and in all countries. His interest in the paper had come from the very great interest he took in the more scientific side of the subject, of absolutely accurate time-keeping, and his knowledge of the very great interest which Dr. Waldo had given to this matter. They must not forget in the large political questions the question which always ought to be before anyone interested in a great industry, viz., what can science do to improve it. That would yield to no question in importance. There was still room for the introduction of science into watchmaking in this country, whether the establishment of large companies was insisted upon or not. One of the most interesting parts of the paper to his mind, was the statement of the different scientific processes carried on under one roof; and it was not only the watch, but science generally which would gain in all these localities. With regard to the watchmaking industry at Coventry, he might say that many years ago he was asked to distribute the prizes at the Science Schools in that town, and he then had to tell the people frankly, that if there was a little more science teaching in Coventry, it would be better for the watchmaking carried on there. That remark did not apply alone to Coventry; it was applicable to many other places. It was in this direction that the extreme value of meetings like the present would be found, for not only did it enable them to see what had to be done, but it furnished the key of the citadel which had to be attacked in the future.

The vote of thanks having been unanimously passed, the meeting adjourned.

Miscellaneous.

COLONIAL AND INDIAN EXHIBITION.

The British Empire.

The façade of the southern entrance to the Central Annexe, on which appears information with regard to the extent of the British Empire, has already proved a source of interest to visitors.

Time.—Five clock faces, whose hands are moved by one set of works, simultaneously proclaim the time throughout the Empire. When the Greenwich clock is at midday, we see that it is 6.57 a.m. at Ottawa; 1.14 p.m. at Capetown; 5.54 p.m. at Calcutta; and 10.5 p.m. at Sydney.

Map.—Under these clocks has been placed a map of the two hemispheres, by Messrs. W. and A. K. Johnston, of Edinburgh and London. It is probably one of the largest maps ever produced. The diameter of each hemisphere is over twenty-one feet. The superficial area is over 700 square feet. The canvas on which it is painted, manufactured on purpose for it by a Kirkcaldy firm, was made the whole size in one piece: as it was, however, found to be too large for convenient handling, it was cut into four pieces, joining at the equator; by this means several assistants were enabled to proceed with the work at the same time, eight weeks being occupied in its construction. The British Possessions are coloured bright scarlet, the sea, lakes, and rivers blue, and the various continents, states, and islands, are distinguished by various colours, and named. As the map is to be exposed to the atmosphere day and night, it has been painted in solid oil colours.

Area, Population and Trade.

Underneath the map of two large hemispheres have been painted up Tables of the area, population, and trade of the British Isles, the Indian Empire, and the British Colonies, which together make up the British Empire.

It would be manifestly impossible to compile Tables like these in such a way as to disarm criticism; but, thanks to the experienced assistance rendered by Mr. J. S. O'Halloran, Secretary to the Royal Colonial Institute, the statistics (see Table, page 753), have been prepared up to the latest possible date. Appended are a few explanatory notes.

Area.—With the exception of those relating to Burma (which is included in the Indian Empire), New Guinea, Bechuanaland, Ascension, Port Hamilton, British North Borneo, Cyprus, and Heligoland, the figures in this Table are taken from the Board of Trade Returns for 1885. These, with the exception of those of British North Borneo (which are extracted from the *British North Borneo Official Gazette*), are given on the authority of the "Statesman's Year Book" for 1886. Under the title Indian Empire, are included, in addition to British India (868,314), Feudatory Native States, with an area of 509,730 miles; Aden and Perim (which are dependencies of the Empire); and Upper Burma, with an area of 190,500 miles. Since the compilation of these Tables, which give the area of Canada as 3,470,392 square miles—as indicated by the Board of Trade Returns, the Colonial Office List, and the "Statesman's Year Book"—an official statement has been received from the Dominion, in which the area is computed at 3,406,542.

The area of the British Empire has quite recently been increased, to a small extent, by the annexation of the Kermadec Islands.

Population.—The returns are based mainly on the Census of 1881, as given in the Board of Trade Returns; but in the case of Australasia, South Africa, Straits Settlements, and British Guiana, they are brought down to 1884. The population of the Gold Coast is that of 1871 only. The figures for New Guinea (which are approximate only), Ascension, Cyprus, and Heligoland, are from the "Statesman's Year Book;" those for Port Hamilton are from "Whitaker's Almanac," and those for British North Borneo (which are approximate only) are taken from the *British North Borneo Official Gazette*: all the rest are from the Board of Trade Returns. The Indian Empire includes the Feudatory Native States with a population of 55,191,742, and the depencies of Aden and Perim; but the population of Upper Burma, which at present can merely be guessed at, has been omitted (the "Statesman's Year Book" estimates it at 1,675,000). The figures for Mauritius, Gibraltar, and Malta are exclusive of the military population; and those for New Zealand do not include the Maoris, who were estimated, in 1881, at 44,097.

Trade.—The figures relating to Cyprus and Hong Kong are taken from the "Statesman's Year Book;" those for British North Borneo are from the *British North Borneo Official Gazette*; all the rest are from the Board of Trade returns.

At first sight it would appear that the total exports from the British Isles to the Colonies ought to be equal to the imports of the Colonies from the British Isles, and that the imports of the one should equal the exports of the other. But a moment's reflection shows that they cannot tally exactly, for, to take but one example, the cargoes of all vessels calling at Valetta go to swell the returns of Malta as well as those of the colony whence they came and whither they go.

In the Table no notice has been taken of fractions.

Additional congratulatory telegrams have been received by H.R.H. the Prince of Wales, from the Viceroy of India, the Governor of Tasmania, and the Governor of Malta.

The band of the 1st West Indian Regiment has arrived in London from the West Indies, and will play for the first time in public at the Exhibition, on Monday next, May 24th.

The number of visitors to the Exhibition for the week ending May 15th was 117,501, making a total since the opening of 245,578.

On Friday, May 13th, the Prime Warden (Mr. W. T. Brand), and the Court of the Fishmongers' Company, entertained the Duke of Cambridge and many members of the Royal Commission, and the Executive Commissioners of the Colonial and Indian Exhibition, at dinner at their hall at London-bridge. H.R.H. the Duke of Cambridge proposed the toast of "The Colonies and our Indian Empire," to which Sir Charles Tupper (Canada), Sir Victor Houlton (Malta), and Mr. E. Buck (India), responded. Sir Philip Cunliffe-Owen proposed the health of the Executive Commissioners, to which Sir Rutherford Alcock (British North Borneo) replied.

On Saturday afternoon, May 15th, the first experiment in washing and manipulating the "blue ground," imported from the Griqualand West Diamond Mines, took place under the direction of Sir Charles Mills, K.C.M.G., acting Executive Commissioner for the Cape of Good Hope, in the Cape Court, in the presence of a number of visitors, amongst whom were the Duke of Manchester, the Right Hon. Osborne Morgan, M.P., Sir John Swinburne, M.P., and others. Several diamonds were found in the course of the operation, which excited an unusual amount of interest. The process will be repeated at stated times during the period of the Exhibition.

On Monday, May 17, the Prince honoured Mr. Leonard C. Wyon with a concluding sitting for his Royal Highness's portrait on the obverse of the commemorative medal of the Exhibition.

On Wednesday, May 19th, the Mohammedan artisans were granted by the Royal Commission a holiday, in order that they might observe their great festival—the *Bakra-íd.*

An interesting feature in connection with the Hongkong Court is the Hongkong Bazaar, which is located in two rooms in the Royal Albert-hall overlooking the Conservatory, and which illustrates the principal commodities which constitute the stock-in-trade of a Chinese retail vendor of assorted goods in Hongkong. Silks, blackwood, ivory carvings, fans, screens, crockery, and other commodities, find a place in this collection, and the bazaar is presided over by some Chinese traders, arrived expressly from Hongkong for the purpose.

RAILWAY FACILITIES FOR COLONIAL AND INDIAN VISITORS.

For the purpose of enabling *boná-fide* visitors from India and the Colonies to obtain, either for themselves or for their wives, female relatives, and children, specially arranged and prepared tickets (single, return, or tourist), to any part of the United Kingdom beyond the distance of fifty miles from the metropolis, a "Central Railway and Tourist Booking-office" has been established in the "Old London" street, opposite the church tower.

Before a ticket can be issued the applicant must obtain from the Commissioner of his colony a voucher of his *boná-fides*, which voucher must be endorsed by the secretary, assistant secretary, or official agent to the Royal Commission. Half-price tickets will be issued to children.

The applicant must state to the booking clerks, before the purchase of a ticket, the specific route by which he desires to perform the outward journey (*i.e.*, that from London.) The booking clerks, whilst prohibited from recommending a particular route in preference to any other, will give general information as to routes, places, stations, hours of train departure, &c. The return journey may be made by any route over any railway, provided it be a route by which ordinary or tourists passengers travelling to London are permitted to return. The return journey may be broken at any place on the direct route; but if any divergence is made therefrom the ticket holder must pay the ordinary fare in each direction between the point of divergence and the place reached from thence. Breaks of the journey may in fact be made at any station on the outward or homeward direct routes, whether such station be named in tourist programmes or otherwise as a station where ordinary passengers may stop. The applicant, after describing the route he desires to take on his outward journey, will be charged for his ticket to the furthermost point to which he intends to travel.

Single tickets will be available for one calendar month from the date of issue. Return tickets will hold good to the 31st of December, 1886. The tickets, which must not be used more than once in the same direction, may be made available from any of the following stations:—Victoria, Kensington (Addison-road), Paddington, Euston, St. Pancras, King's-cross, Liverpool-street, Broad-street, London-bridge, Cannon-street, Ludgate-hill (to stations north of London), Holborn-viaduct, Moorgate-street, Charing-cross, and Waterloo.

An inquiry office and waiting-room, provided with the time-table books of all the railway companies, has been attached to the railway office of the Royal Commission, whereat visitors may obtain general railway information. The office is open daily from 10 a.m. to 10 p.m.

AREA, POPULATION, AND TRADE OF THE BRITISH EMPIRE.

	Area.		Population.		Imports.		Exports.	
	Square Miles.				Total.	From Colonies.	Total.	To Colonies.
					£	£	£	£
British Isles		120,832		35,241,482	390,018,569	95,812,911	295,967,583	88,303,634
					Total.	From Brit. Isles.	Total.	To British Isles.
Indian Empire		1,574,516		253,982,595	68,156,654	49,711,562	89,098,427	36,984,034
Dominion of Canada		3,470,392		4,324,810	23,917,200	8,921,510	18,782,156	8,986,897
Newfoundland		40,200		179,509	1 682,457	642,528	1,368,153	322, 27
Australasia :—								
New South Wales	311,098		921,268		22,826,985	11,423,047	18,251,506	7,683,886
Victoria	87,884		961, 75		19,201,633	9,149,076	16,0 0,465	7,74 ,415
South Australia	903,690		312,781		5,749 353	2,983,296	6,623,704	4,081,864
Queensland	668,497		309,913		6,381,976	2,520,863	4,673,864	1,715,391
Western Australia	1,060,000		31,700		521,167	222,940	405,693	279,660
Tasmania	26,215		130,541		1,656,118	642,102	1,475,857	3 9,708
New Zealand	104,458		564,304		7,663,888	4,934,493	7,091,667	5,158,078
Fiji	7,740		128,614		434,522	...	345,344	35,542
New Guinea	86,360		135,000		...	...	...	...
		3,255,942		3,495,397				
South Africa :—								
Cape of Good Hope	219,700		1,249,824		5,260,697	4 023,819	7,031,744	6,602,193
Bechuanaland	185,000		...		...	...	...	...
Natal	18,750		424,495		1,675,850	1,310 452	9 7,918	721,190
		423,450		1,674,319				
St. Helena and Ascension		82		5, 24	*63,786	*27,931	*23,406	*1,164
Ceylon		25,365		2,763,984	4,811,451	1,315,345	3,161,262	1,8 2,828
Mauritius		713		377,373	2,963,152	692,430	3,941,757	508,331
Straits Settlements		1,472		540,000	18,676,766	4, 82,920	17,260,138	3,845,362
Hong-Kong		30		160,402	4,000,000	3,218,946	2,000,000	1,052,302
Port Hamilton		5		2,000	...	...	...	...
British North Borneo		30,000		150,000	96,282	...	2,551	...
Labuan		30		6,298	84,869	1,554	85,741	...
British Guiana		109,000		264,061	1,999,448	1,099,504	2,322,032	1,777,376
West Indies :—								
Jamaica	4 362		585 536		1,595,262	910,194	1,518,024	643,971
Trinidad	1 754		153,128		3,083,870	887,011	2,769,727	863,290
Windward Islands	784		311,413		1,611,483	670,955	1,834,388	797,194
Leeward Islands	665		119,546		476,457	207,637	466,759	160,903
Bahamas	5,390		43,521		181,494	37,329	122,351	35,771
		12,955		1,213,144				
Bermudas		19		13,948	283,440	75,416	88,622	2,557
British Honduras		6,400		27,452	237,538	127,602	317,449	205,032
West Africa :—								
Sierra Leone	468		60,546		4 5,424	323,572	377,055	156,730
Gambia	69		14,150		212,122	87,099	199,483	18,753
Gold Coast	18,784		408,070		537,339	403,788	467,228	330,997
Lagos	1,069		75,270		538,221	338,318	672,414	240,794
		20,390		558,036				
Gibraltar		2		18,381	...	...	...	...
Malta		119		149,782	13,343,789	122,899	12,908,492	3,1 0,319
Cyprus		3,584		186,173	304,375	...	287,521	...
Heligoland		1		2,001	...	...	...	...
Falkland Islands		6,500		1,553	67,848	60,962	101,338	98,468
Total		£9,126,969		305,337,924				

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* These figures refer to St. Helena only.

Tickets for places within fifty miles from the metropolis can be obtained by visitors under the joint booking system at the Subway Booking-offices adjoining the south court of the Indian galleries. In this case the vouchers mentioned above are not necessary. Tickets to the Continent will not be issued at the Exhibition.

Fruit, Flower, and Vegetable Shows.

The Royal Commission has arranged with the Royal Horticultural Society for the following fruit, flower, and vegetable shows to be held in the Conservatory during the season. They will be open free to visitors to the Exhibition:—Pot roses, azaleas, &c., Tuesday, May 25th; orchids, Tuesday, June 8th; pelargoniums, &c., Tuesday, June 22nd; National Rose Society's show, Tuesday, July 6th; flowers and fruit, Tuesday, July 13th; National Carnation and Picotee Society's show, Tuesday, July 27th; plants and flowers, Tuesday, August 10th; cottagers' show, Tuesday, August 24th; grapes, dahlias, &c., Tuesday, September 7th, and Wednesday, September 8th; hardy fruits, Tuesday, October 12th, and Wednesday, October 13th; chrysanthemums and vegetables, Tuesday, October 26th, and Wednesday, October 27th.

On the dates September 8th, October 13th, October 27th, the hours of closing will be 10 p.m., so as to allow the exhibits to be seen under the influence of the electric light.

BUTTERINE OR OLEOMARGARINE.

By P. L. Simmonds.

The enormous quantity of butterine or artificial butter that is now flooding the markets of Europe, is awakening public attention to the deception which is so generally practised, of passing it off for the pure article of butter churned from milk. It is highly important that the dairy products, milk, butter, and cheese, should be obtainable in their genuine state; as dietetic articles they are of the greatest importance for nutrition, and yet they are now exceedingly difficult to obtain unadulterated. The last-named article, cheese, was formerly supposed to be free from adulteration in any of its numerous forms and varieties, but the skilful Americans have lately entered extensively into the manufacture of lard cheese as well as lard butter. Stringent measures are required to detect and punish those concerned in these shameful deceptions, and they are likely, we hope, to be soon adopted, so that all food articles at least may be branded and sold under their proper names.

In a printed Parliamentary paper received from our Ambassador at Washington, the American Minister of Agriculture reports that "one-half of the receipts of butter in New York is classed as butterine, an article produced by the admixture of lard and good butter, half and half. Suine comes under the head of butterine, and is similarly made, only having a larger portion of lard. Oleomargarine is, however, manufactured from grease of any and all kinds. For this purpose tallow, lard, cotton-seed, pea-nut, and other oils, are sought for and obtained from all sources and from all countries. These fats are deodorised and neutralised by treatment with nitric acid, mixed with milk, cream, or poor butter, and churned. The acid in this composition is, of course, very deleterious, and, in proportion to its quantity, is the resultant injury. Many of these products can scarcely be told from genuine butter, even by experts, and tests by microscope and sulphuric acid are essential to determine their true character."

When people come to know that rancid butter is as certainly poisonous as rancid tallow, they will be more cautious about eating it. If a mass of crude animal fat be heated to a temperature not exceeding 120° Fahr. the whole of it will melt, and the product will be perfectly odourless and available for domestic and cooking purposes; but it has neither the flavour or qualities of pure butter. Microscopic examination with polarised light is the most reliable means of distinguishing pure butter from that which contains an admixture of other less palatable fats. Even in its pure state, under its right name, oleomargarine can never become, however perfect, a successful rival to good butter. But the fraud is great when it is sold as such, or even to adulterate butter.

Laws are in force in many of the States of the American Union, requiring manufacturers to brand such articles according to their composition; but, unfortunately, when the products reach the points of distribution, the removal of the brands subjects the consumer to deception.

So far back as 1877, it was publicly stated in the New York papers that there were more than fifty artificial butter factories in that city. The cost of manufacture of oleomargarine was then about 6d. per lb., and the selling price to wholesale dealers 1s., so that, so far as the saving is concerned, there is very little over the cost of genuine butter. The manufacture commenced in America about 1873, when the Oleomargarine Company turned out one or two tons daily, and were then enlarging their works so as to produce twelve tons per day. Large shipments are made thence to Holland and France. There are also factories at Baltimore, Chicago, St. Louis, Cincinnati, Boston, Pittsburg, Providence, and Newhaven. From statistics prepared by Mr. Nimmo, of the United States Department of Agriculture, it appears that more than one-third of the American exports of butter are sworn to be oleomargarine, and there is a large additional quantity which goes out as butter under sworn manifests.

Four years ago the manufacture of oleomargarine in the States was estimated at 500,000 lbs. daily, or 1,397,321 cwt. yearly, and one-half the butter sold in New York is bogus butter. Great progress has been made in Europe in the production of oleomargarine. Large quantities are manufactured at Vienna, and of a visibly improved quality, so that several makes of the Austrian product now compete in the market with the best quality of American goods. Paris now also supplies considerable quantities of a good quality of the article, which is usually selling at from 10 to 15 per cent. less than the American. The manufacture of oleomargarine in Russia is also of some importance, but generally consists of poor quality.

It was stated some four or five years ago, by a correspondent in the *Daily News*, that there were then twelve large factories in Holland for the manufacture of butterine, and from 50,000 to 60,000 tubs (each containing about 30 lbs.) were required weekly for shipping this product. The raw material oleomargarine was received from the States, and after purification, when mixed with a certain quantity of new milk, was exported, chiefly to England.

The American Consul at Amsterdam reported to his Government, in 1882, that the imports of oleomargarine into the Netherlands from the United States, was about 80,000 tierces in the year.

The increase in ten years in our imports of foreign butter is remarkable. The principal countries from whence we drew supplies, are shown in the following figures for 1874:—

	cwts.
Sweden	23,292
Denmark	226,053
Germany	135,027
Holland	351,605
France	713,251
United States	36,307
Canada	50,282
	1,535,817

Taking the years 1884 and 1885, the foreign countries chiefly supplying us with butter were the Scandinavian States, Germany, Holland, France, the United States, and Canada. The respective proportions being:—

	1884. cwt.	cwt.
Sweden	101,522	—
Norway	31,156	—
Denmark	335,067	377,596
Germany	146,400	145,948
Holland	1,113,212	1,080,334
France	509,715	450,949
United States	100,151	78,245
Canada	55,437	—
	2,391,961	2,133,072

All other countries contributed less than 100,000 cwt. Sweden, Norway, and Canada are not specified in 1885. The aggregate exports of butter from the Dominion of Canada have declined one-half; in 1880 they reached 184,640 cwt., in 1884 they fell to 84,739 cwt.

It is somewhat singular that Holland, which has decreased in the last ten years in the number of its live stock (the cows formerly averaging about 1,000,000), should have nearly quadrupled its export of butter.

One of the Dutch butterine manufacturers, who is an eminent chemist, in his trade circular boldly takes credit for the substitution, asserting that "wherever through the progress of technical knowledge a valuable substance has been superseded by a surrogate, public opinion has, after a short commotion, accepted the position of affairs, when it was obvious that the new intruder possessed definite identical qualities." And he instances the substitution of artificial alizarine for madder, beetroot for cane-sugar, vanilin essence from fir trees for vanila pods, &c.

It is impossible to separate butter from butterine in the aggregate imports from the two countries from which the adulterated or artificial article chiefly comes; but the following are the figures of the imports from each:—

	Holland. cwts.	United States. cwts.
1880	810,509	277,790
1881	745,536	174,246
1882	921,182	51,246
1883	986,994	120,039
1884	1,112,212	100,151
1885	1,080,334	78,245

Imports of butter and butterine into the United Kingdom:—

	cwts.
1861	992,772
1871	1,334,783
1881	2,047,341
1885	2,400,565

The average annual consumption of foreign butter per head in the United Kingdom was in

	lbs.		lbs.
1877	5·34	1881	6·36
1878	5·82	1882	6·72
1879	6·57	1883	7·18
1880	7·42		

In the last few years our imports of foreign butter and butterine have steadily increased, as the following figures will show:—

	cwts.
1881	2,047,341
1882	2,169,717
1883	2,334,473
1884	2,475,436
1885	2,400,565

The slight falling off last year is attributable to the depression of trade.

As we pay over £12,000,000 sterling for this food substance annually, it is but fair that we should get what we expect, viz., pure butter from milk instead of butterine. The effect of the large introduction of these mixed compounds has been to reduce the wholesale price of butter 10s. per cwt. since 1878.

FORESTS OF JAPAN.

The area of Japan is about 96,000,000 acres, and the forest area, exclusive of the Loo Choo and the Bonin Islands, is about 29,000,000 acres. The forests are held in nearly equal proportions by Government and by private owners. Forestry has long been made a study in Japan, and it is stated in a recent report of the United States Commissioner of Agriculture that no people are more skilled in grafting and dwarfing trees than the Japanese. The Government Forestry Department is now an important branch of the State. The head office is in the capital, Tokio, but in each of the forty-four *Ken* or States, into which Japan is divided, there is a branch office from, which the respective forests and plantations are managed. During the days of the old rulers, each lord had his own forestry laws, all of which were very strict; one of these made it a punishable offence to be found in the forest after nightfall. Since the new *regime* the forestry laws have been consolidated, and their old feudal strictness somewhat abated; but the existing laws are still strict enough to secure the due preservation of the forests. In Tokio there is a Government school of forestry which was established three years ago, and is now attended by 150 pupils. Some of these pupils are preparing themselves for practical work in the State forests; others are the sons of landowners and farmers acquiring a scientific knowledge of arboriculture in order to qualify themselves for the efficient management of their own lands. The curriculum in the forestry school includes botany, the chemistry of the soil, a little natural philosophy, surveying, and the practical work of planting and rearing trees. Illustration is given to the pupils by Japanese officials, who have themselves studied forestry in the schools of Germany. Large plantations have been formed under Government auspices, and every year the area of forest land is being added to—cedars, oaks, spruces, and firs being the trees more generally planted. Within the last few years an important experiment has been made in the introduction into Japan of the seeds of trees and shrubs from other countries. Tea is extensively cultivated, but it was only in 1879 that the first coffee berries were brought from the Sandwich Islands and planted in Japan, and great hopes are entertained of the success of this experiment, from a commercial point of view. The cinchona tree was introduced from India in 1878, but the climate of Japan does not appear to be favourable to it, and in 1880 large importations of forest trees were made from Europe and America, and planted in the experimental gardens of the forestry department at Tokio. Some were failures, and others took favourably to the country—the list including several firs, oaks, and maples, the birch, the German larch, lime, ash, *pinus webbiana*, and other trees, which will in time form an important addition to the timber supply of the country. Extending over 15 degrees of latitude, and with high central ridges of mountains on the larger islands, the climate of Japan differs considerably in the north and south, on the plain and in the mountains, so that the vegetation partakes both of tropical and temperate zone characteristics. The country itself may be divided into five distinct tree regions or zones. In the first the temperature is high, and the forests consist of broad-leaved evergreen trees, then comes the zone of the oak and the beech, and other broad-leaved deciduous trees; next that of the family of cedars, among others the *Thuias* and *Retinosporas* for which the country is remarkable. Higher still is the region of the firs and pines, the conifers including many of the finest specimens of the *Abies veitchii*. Chief, however, among the trees of Japan are the *Cryptomeria japonica* and *Retinospora obtusa*, which attain to a height of about 120 feet, and a girth of 20 feet. The United States Commissioner of Agriculture says, that to those who have only been accustomed to see small dwarf specimens of the Japanese *arbor vitæs* and conifers used for lawn decorations, nothing is more astonishing than the great slabs of wood which such trees supply in their native country. Of such slabs many specimens are seen in Japan, and the ornamental woods are also very numerous. A very useful Japanese hardwood is the *Keyeki*, which has a reddish hue; and there are many varieties of oak. From one of the trees grown in Japan—the *Bronsonetia papyrifera*—the inner bark is taken and manufactured into paper, while from one of the climbing plants the woodmen make their clothing. The wood is steeped in water, then beaten with hammers, and the fibrous mass thus obtained is woven into cloth, which is dyed a deep blue colour. In the way of timber, the Japanese are able to supply the greater part of their own wants, and as the houses are largely built of wood, the quantity required is very considerable. A large quantity of timber is exported to China, and a small quantity is imported from America. In Japan there are large numbers of ponds in which timber is preserved. These are usually constructed near the mouth of a river, and into them fresh and sea water is allowed to flow, in the proportion of six parts salt to four parts fresh. Should there be a larger proportion of salt water, the timber is apt to become black; if a larger proportion of fresh water, the wood is liable to attack from worms. The ponds are about five feet in depth, and by means of canals many of them are often connected. The timber is piled in the form of a cube, and is kept in the pond from two to five years before being used; the trees most frequently treated in this way being the *Retinosporas* and *Cryptomeriæ*; a part of the preserving process being the thorough washing and re-arrangement of the wood twice a-year. Some of the ponds are made large enough to contain 10,000 pieces of timber.

Correspondence.

LONDON SEWAGE.

Mr. J. Bailey-Denton sends the following note in explanation of the Table printed in the *Journal* of the 7th inst.:—By the construction of Sir Joseph Bazalgette's extension of the metropolitan outfalls, and the purchase of Canvey Island (4,500 acres), not only would all the uncertainties of chemistry and the contradictions of chemists (amply illustrated at the recent discussion) be avoided by removing the discharged sewage entirely out of the river; but this desirable and complete act could be effected for a less charge upon the ratepayers than the experimental, incomplete, and unsatisfactory proceedings of the Board. It appears to me like throwing dust in the eyes of the ratepayers to talk of the great expense involved in Sir J. Bazalgette's extension, when the interest on the outlay will be less than the annual cost of chemicals, whilst the permanent works at the outfalls will certainly not cost less than those required on the island. But perhaps the most important feature in favour of the island is that all difficulty in relation to the sludge will be overcome by its acquisition, for if the Board persist in chemical precipitation at the outfalls—which I cannot think possible—the island will be found a fit place for the pressed sludge, seeing that no possible nuisance can occur, and the island itself will be made more valuable by raising its surface above tide.

THE PROPOSED FISHERY DEPARTMENT.

Dr. Francis Day writes to say that in the report of his remarks in the discussion on Mr. Willis-Bund's paper (*ante* p. 734, col 2, line 9 from bottom), the words "to practical fishermen" should be added after the words "he did not know that the scientific station at Naples had been of much use."

Notes on Books.

International Exhibition of Industry, Science, and Art. Edinburgh, 1886. Official Catalogue.

The Book of Old Edinburgh and Handbook to the Old Edinburgh Street, designed by Sydney Mitchell, Architect for the International Exhibition of Industry, Science, and Art; with Historical Accounts of the Buildings therein, reproduced by J. C. Dunlop and A. H. Dunlop. Edinburgh: T. and A. Constable.

The Exhibition, which was opened lately by H.R.H. Prince Albert Victor, covers seven acres of ground, and the other eighteen acres of the West Meadows, where the building is situated, have been laid out as a promenade. The cost of the buildings has been about £30,000; in addition to this the reproduction of the "Old Edinburgh Street" cost about £4,000. The installation of the electric light, which consists of upwards of 3,200 lamps, cost £5,000. The exhibits are divided into nineteen classes, as follows:—1. Minerals, mining, quarrying, and metallurgy. 2. Pottery, glass, and kindred industries. 3. Chemistry, pharmacy, and food. 4. Animal and vegetable substances and their manufacture. 5. Paper manufacture, stationery, printing and bookbinding. 6. Prime movers. 7. Manufactures in metal. 8. Railway, tramway, and vehicular appliances. 9. Civil and military engineering, building construction, shipbuilding. 10. Furniture and decoration. 11. Scientific appliances. 12. Educational appliances. 13. Sea industries. The "Old Edinburgh Street," which has been planned in emulation of the "Old London Street" of the Exhibitions at South Kensington, consists of a reproduction of some of the most historically interesting buildings existing in Edinburgh before the end of the 17th century, all of which have now been swept away. "The Book of Old Edinburgh" contains an account of the homes represented, and anecdotes of the inhabitants of the old town.

Facsimile of the Ancient Book of the Weavers' Company, the original of which is in the possession of the Company. London: Photo-lithographed from the original by W. Griggs.

This folio volume consists of an exact representation of the pages of the curious volume of the Weavers' Company, which contains the statutes, ordinances, and regulations of the Company, beginning with the reign of Henry VII. and the year when Sir Hugh Clopton was Lord Mayor. The late Sir Thomas J. Nelson, City Solicitor, projected this work, and intended to prefix a descriptive introduction, but this was prevented by his death.

General Notes.

Congress of Hydrology and Climatology.—The first international Congress of Hydrology and Climatology will be held at Biarritz, in October, 1886, under the honorary patronage of the Minister of Commerce, and the presidency of Dr. Durand-

Fardel. The Congress will last eight days (from 1st to 8th October). At the close, excursions will be made to the different thermal and sanitary stations in the Pyrenean district. Communications and inquiries should be addressed to M. le Dr. Garrigou, Toulouse (from the 1st November to the 31st May)—Luchon (Haute-Garrone), from the 1st June to the 31st October.

INLAND NAVIGATION.—The second International Congress on Inland Navigation will be held this year at Vienna from the 15th to the 19th of June. All communications should be addressed to the Organising Commission, I. Eshenbachgasse, No. 11, Vienna.

SUGAR REFINING BY LIGNITE.—The *Année Scientifique* states that M. Kleeman, of Schœningen, has discovered a new method for purifying beetroot juice by lignite, which it appears possesses the property of purifying liquids. If pulverised lignite is mixed with a turbid fluid, or with one having a disagreeable taste or odour, a deposit is rapidly formed, and the liquid soon becomes clear and loses its bad smell. Cane, as well as beetroot sugar, may be refined by lignite, and the process is very economical. The sugars produced in this way have an agreeable taste, and the syrups completely lose their taste of beetroot.

MEETINGS OF THE SOCIETY.

FOREIGN AND COLONIAL SECTION.

At Eight o'clock:—

TUESDAY, MAY 25.—"Cyprus since the British Occupation." By G. GORDON HAKE. Major-General Sir ROBERT BIDDULPH, K.C.M.G., C.B., will preside.

INDIAN SECTION.

Friday evenings, at Eight o'clock:—

MAY 21.—"Everyday Life of Indian Women." By Capt. RICHARD CARNAC TEMPLE. JAMES GIBBS, C.S.I., C.I.E., will preside.

CANTOR LECTURES.

The Sixth Course will be on "Animal Mechanics." By B. W. RICHARDSON, M.A., M.D., F.R.S.

Lecture IV.—May 24.—Some special Mechanisms.

Lecture V.—May 31.—Mechanisms continued; and Review in regard to practical applications.

ADDITIONAL LECTURES.

The course of Elementary Lectures on "Electricity" will be continued by Professor GEORGE FORBES, on Saturday afternoons, at Three o'clock:—

Lecture VI.—May 22.—Electrical Measurement.

MEETINGS FOR THE ENSUING WEEK.

MONDAY, MAY 24...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. (Cantor Lectures.) Dr. Richardson, "Animal Mechanics." (Lecture IV.

Geographical, University of London, Burlington-gardens, W., 2½ p.m. Annual Meeting.

Linnean, Burlington-house, W., 8 p.m. Anniversary Meeting. Election of Council and Officers. President's Address and postponed communication on "Forms of Seedlings, and causes thereof."

TUESDAY, MAY 25...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. (Foreign and Colonial Section.) Mr. G. Gordon Hake, "Cyprus since the British Occupation."

Royal Institution, Albemarle-street, W., 3 p.m. Prof. A. Gamgee, "The Function of Circulation."

Medical and Chirurgical, 53, Berners-street, Oxford-street, W., 8½ p.m.

Civil Engineers, 25, Great George-street, S.W., 8 p.m. Annual General Meeting.

Anthropological, 3, Hanover-square, W., 8 p.m. Mr. Reginald Stuart Poole, "The Ancient Egyptian Classification of the Races of Man."

Horticultural, South Kensington, S.W., 1 p.m. Show of Pot Roses, Azaleas, &c.

WEDNESDAY, MAY 26...Geological, Burlington-house, W., 8 p.m. 1. Dr Henry Hicks, "Further Proofs of the Pre-Cambrian Age of Certain Granitoid, Felsitic, and other rocks in North-Western Pembrokeshire." 2. Prof. T. G. Bonney, "Some Rock-specimens Collected by Dr. Hicks in North-western Pembrokeshire." 3. Mr. Aubrey Strahan, "The Glaciation of South Lancashire, Cheshire, and the Welsh Border."

Royal Society of Literature, 4, St. Martin's-place, W.C., 8 p.m.

THURSDAY, MAY 27...Royal, Burlington-house, W., 4½ p.m.

Antiquaries, Burlington-house, W., 8½ p.m.

Royal Institution, Albemarle-street, W., 3 p.m. Prof. A. Macalister, "Habit as a factor in Human Morphology."

Telegraphic Engineers and Electricians, 25, Great George-street, S.W., 8 p.m. 1. Capt. P. Cardew, "The Telephone as a Receiving Instrument in Military Telegraphy." 2. Capt. H. R. Sankey, "A Problem relating to the Economical Electrolytic Deposition of Copper."

FRIDAY, MAY 28...Victoria Institute (at the HOUSE OF THE SOCIETY OF ARTS), 8 p.m. Annual Meeting.

Royal Institution, Albemarle-street, W., 8 p.m. Weekly Meeting, 9 p.m. Prof. Oliver Lodge, "Electrical Depositions of Dust and Coke."

English Goethe Society, Westminster Town-hall, Caxton-street, S.W., 8 p.m. Inaugural Meeting, Address by the President, Professor F. Max Müller, "World-Literature, illustrated by newly discovered Letters from Goethe to Carlyle."

Quekett Microscopical Club, University College, W.C., 8 p.m.

Clinical, 53, Berners-street, W., 8½ p.m.

Browning, University College, W.C., 8 p.m. Rev. H. J. Bulkeley, "The Reasonable Rhythm of some of Mr. Browning's Poems."

SATURDAY, May 29...Royal Institution, Albemarle-street, W., 3 p.m. Prof. G. G. Stokes, "Light, with special reference to Effects resulting from its Action on various Substances."

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FRIDAY, MAY 28, 1886.

All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

NOTICES.

CONVERSAZIONE.

The Society of Arts Conversazione will be held, by permission of the Royal Commission, at the Colonial and Indian Exhibition, South Kensington, on Friday, the 16th of July next.

Each member will receive a card for himself, which will not be transferable, and a card for a lady. In addition to this, cards will be sold to members of the Society, or to persons introduced by a member, at the following prices:—Until the 3rd of July, 7s. each; after that date 10s. each, except on the 16th July, when the price will be 15s.

The Council, however, reserve the right of stopping the sale of tickets or of raising the price, if it is found necessary, in order to restrict the number of visitors within reasonable limits.

Tickets will only be supplied to persons presenting members' vouchers (forms of which can be obtained from the Secretary), or a letter of introduction from a member.

Members can purchase these additional tickets by personal application, or by letter addressed to the Secretary. In all cases of application by letter, a remittance must be enclosed. Each ticket will admit one person, either lady or gentleman.

Light refreshments (tea, coffee, ices, &c.) will be supplied at the usual buffets. No refreshments can be obtained by purchase. It will greatly facilitate the arrangements if members requiring additional tickets will apply for them at as early a date as convenient. The members' invitations will be issued early in June. Visitors' tickets can be purchased from the present date.

There will be no admission to the Exhibition on this evening except by special ticket, and no tickets can be purchased at the Exhibition.

Further particulars as to the arrangements will be announced in future numbers of the *Journal.*

CANTOR LECTURES.

The fourth lecture of the course on "Animal Mechanics" was delivered by Dr. B. W. Richardson, F.R.S., on Monday evening, 24th inst.

The lectures will be printed in the *Journal* during the summer recess.

ADDITIONAL LECTURES.

Professor George Forbes delivered the sixth and last lecture of his course of elementary lectures on "Electricity" on Saturday afternoon, 22nd inst., when he dealt with the the chief practical applications of electricity.

The lectures will be printed in the *Journal* during the summer recess.

EXAMINATIONS, 1886.

The list of successful candidates in the Examinations for the present year has been printed, and is forwarded to the Institutions in Union with the present number of the *Journal.* Copies will also be sent to the various committees for the successful candidates.

Proceedings of the Society.

APPLIED CHEMISTRY & PHYSICS SECTION.

Thursday, May 13, 1886; Professor James Dewar, M.A., F.R.S., Vice-President of the Society, in the chair.

The paper read was—

THE SCIENTIFIC DEVELOPMENT OF THE COAL TAR COLOUR INDUSTRY.

By Prof. R. Meldola, F.C.S., F.I.C.

The subject on which I propose to address you this evening has been brought under the notice of the Society of Arts on former occasions, and was only last year thoroughly treated of by Dr. W. H. Perkin, the pioneer of this branch of manufacture, in his presidential address to the Society of Chemical Industry. It has, moreover, quite recently furnished materials for a lecture at the Royal Institution by Sir Henry Roscoe, so that I feel in some measure obliged to apologise for again bringing forward a topic upon which it may appear to chemists that nothing particularly new remains to be said. Having, however, been intimately associated with this branch of chemical industry for many years, I have had exceptional opportunities of watching its development, and of forming ideas upon the causes of its progress, which may justify my engaging your attention upon the present occasion.

The manufacture of coal-tar products is a subject which offers distinct advantage for popular treatment, both on account of the practical utility of the products, and the striking and beautiful colour phenomena which they present. But I do not propose now to avail myself of these advantages, because I think there is a more serious aspect of the subject than the mere enumeration of the names, chemical formulæ, and mode of preparation of the recently discovered products. I must take it for granted that those present this evening are familiar with the fact that out of coal tar there are obtained series of hydrocarbons from which are prepared nearly all the dye-stuffs at present in use; that the introduction of these artificial colouring matters has revolutionised the tinctorial industries, and that the tar of gas works, which was formerly a waste product and a nuisance, is now a valuable source of revenue to the gas companies. It is, doubtless, known to you also that, besides colouring matters, there are obtained from the same hydrocarbons artificial perfumes, and drugs which rival quinine in efficiency; and that quite recently a substance has been discovered by Dr. Fahlberg, which goes by the name of "saccharine," and which is stated to possess 220 times the sweetening power of cane sugar.* But I must content myself by merely pointing to such discoveries as triumphs which the chemist, by his "so potent art," has achieved in recent times, because I want to bring home to English manufacturers one particular point in connection with this industry, and the Chemical Section of the Society for the Encouragement of Arts, Manufactures, and Commerce seems to me to be the right place for so doing. It cannot be denied that the coal tar industry has for some years past been migrating from this country, the land of its birth, to the Continent of Europe. Of the causes of this decline assigned by Dr. Perkin and others who have expressed opinions upon the subject, I do not now propose to touch upon those which may be considered as purely politico-economical ones, such as Free Trade, the Patent-laws, or the available energy of a British as compared with a German workman under the stimulus of a certain amount of weekly wage. These and kindred questions—such as the cost of railway carriage, or the relative ideas of "making a manufacture pay" which may exist in the British and Teutonic minds—have, doubtless, a most important bearing upon the main subject, but their discussion would occupy far too much time, and would, moreover, be out of place in this Section. I might even go so far as to express a private belief that if this portion of the subject were handed over for legitimate treatment by economists, the conclusions arrived at (if any) would hardly be commensurate with the amount of discussion which would be evoked. In fact, it appears to me that although, in a general way, each of the causes mentioned must be a factor in determining the success of any branch of manufacture, it is quite impossible to assign its true value to each of these factors; and in the case of the present industry I am persuaded that it is now a question of chemical and not of economic science that is pressing for consideration.

It will, I think, be conceded that the manufacture of coal-tar products is *par excellence* the most scientific of the chemical industries. This high position may fairly be claimed for the industry when we consider the number and complexity of the products, the delicacy of many of the reactions employed, the special arrangements of plant required, and the intimate knowledge of the chemistry of the aromatic compounds which the colour chemist must at the present time possess. Moreover, the industry is of comparatively recent growth—it has been born and has reached its present development within the last thirty years, so that the successive phases of its evolution can be clearly traced. For these reasons the subject is well calculated to throw light upon the general question of technical chemical education, a question of which the importance to the country at large now bids fair to become duly recognised.

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* The substance referred to is orthobenzoyl-sulphonimide, $C_6H_4\left<\begin{matrix}CO\\SO_2\end{matrix}\right>NH$. For details, see a paper by I. Levinstein, Journ. Soc. Chem. Ind., Feb. 1886, p. 75.

In treating of the industrial development of a branch of chemical manufacture, it is important that we should begin with a distinct idea of the products themselves. I must claim the indulgence of chemists if at this stage I find it necessary to go over somewhat old ground, and to state facts with which so many are familiar. It would, of course, be quite impossible to give, on the present occasion, anything like a complete chronological list of the various colouring matters, and it would be equally impossible for me to enter into the discussion of the chemical structure of the beautiful compounds which are now to be met with in the market. If, later on, I find it necessary to enter into questions of chemical constitution, it will be chiefly with the object of illustrating general principles by appealing to particular cases. In the brief historical sketch which I now propose to lay before you, I shall mention only those discoveries which may be considered to mark distinct commercial epochs in the development of the industry. The successive steps in this development will furnish us with one of the most striking illustrations of the utilisation of scientific discovery for industrial purposes, and the reaction of industry upon pure science.

Commencing in the year 1856, the foundation of the coal-tar colour industry was laid by Perkin, by the discovery of mauve, a violet dye, obtained accidentally in the course of an investigation having for its object the preparation of quinine by an artificial synthesis. In 1860, magenta, which had formerly been made in small quantities by expensive processes, was rendered a product of the first order of commercial importance, by the discovery of the arsenic acid process by Medlock and E. C. Nicholson simultaneously. During this same year, phenylated blues were first produced by Girard and De Laire, by the action of aniline upon magenta base at a high temperature These blues had but a limited application owing to their insolubility, and their value was enormously enhanced by Nicholson's discovery in 1862, that these colours could be converted into soluble sulphonic acids. The first azo-colour, amidoazobenzene, a basic yellow dye, was introduced in 1863, by the firm of Simpson, Maule and Nicholson, under the name of "aniline yellow." In this same year the methylic and ethylic derivatives of magenta were manufactured by the same firm, under the name of "Hofmann violets," in honour of their discoverer. "Azodiphenyl blue," the first of the colouring matters now known as indulines, and Manchester yellow, appeared in 1864; and in 1866 "Bismarck brown" (triamidoazobenzene) was first manufactured at Manchester. The same year (1866) was marked by the introduction of Coupier's nitrobenzene process for the manufacture of magenta. In 1868, Graebe and Liebermann gave to the world their great discovery of the chemical constitution of alizarin, and in the following year the manufacture of this colouring matter from anthracene was commenced. The first members of the great family of the "phthaleïnes," viz., galleïn and fluoresceïn, were discovered by Baeyer in 1871; and the first technical application of this discovery was made in 1874 by Caro, who introduced the beautiful pink tetrabromfluoresceïn into commerce, under the name of "eosin." Diamidoazobenzene was discovered by Caro and Witt independently in 1875, and was introduced into commerce by the latter as "chrysoïdine." A great impetus was given to the technical production of azo-colouring matters by this discovery, the napthol oranges and other "tropœolines," fast-red, the ponceau scarlets, &c. appearing in 1878. Methylene blue and acid magenta were introduced by Caro in 1877, and in the same year the old and fugitive "aniline yellow" was converted into a valuable acid yellow by Grässler, who patented a process for converting the base into a sulphonic acid. Malachite green was introduced in 1878, and in 1879 the first member of the now important group of secondary azo-compounds appeared under the name of Biebrich scarlet. It is these secondary azo-scarlets, and especially the "croceine scarlets" (discovered in 1881) which are exterminating the cochineal industry. The year 1880 was marked by the brilliant discovery of the constitution of indigo, and the synthesis of this colouring matter by Baeyer, a discovery which is none the less a triumph of synthetical chemistry because the manufacture is not at present successful from a commercial point of view. Indophenols were introduced by Koechlin and Witt in 1881, and in 1883 appeared Caro's first patent for the production of colouring matters of the rosaniline group by the method of "condensation" with phosgene gas, in the presence of suitable condensing agents.

This chronological record comprises nearly all the chief colouring matters from coal-tar which are or have been of industrial value. It is important to note that the list, even as it stands in the form of a bald statement of facts in chemical history, reveals the existence of that fundamental law of the "survival of the fittest." Old products have been displaced by newer ones, as fresh discoveries were made, or processes improved, and to the chemist it is of interest to observe how this development of an industry has gone on *pari passu* with the development of the science itself. The moral conveyed to the manufacturer is sufficiently obvious. If we are to recover our former supremacy in this industry, we must begin by dispelling conservative ideas—we must realise the fact that no existing process is final, and that no product at present sent into the market is destined to survive for an unlimited period. The scientific manufacturer must be brought to see that present success is no guarantee for future stability, and unless he realises this position in its fullest significance, he may find the sale of his standard products gradually falling off, or be compelled to wake up to the unpleasant fact that his competitors are underselling him, owing to improved methods of manufacture.

It may appear to many that I am here simply preaching the doctrine of progress, and that the remarks which I have offered are mere truisms. Unfortunately, the facts of the case render this appeal necessary. It must never be forgotten that the coal-tar colour industry is essentially of English origin. It was Faraday who first discovered benzene in 1825; it was Mansfield who, in 1847, first isolated this substance in large quantities from coal-tar, and showed how nitro-benzene could be manufactured therefrom. The beginning of the colour industry was Perkin's discovery of mauve; and the introduction of the new colour into dyeing establishments was due to the example set by Messrs. Pullar, of Perth, in 1856. The manufacture of magenta on a large scale was the result of the discovery of the arsenic acid process by Medlock and Nicholson; and the phenylic blues were made commercially valuable by Nicholson. The first azo-colours, "aniline-yellow" and "Manchester brown," as well as Manchester yellow (dinitro-α-naphthol) were manufactured in this country. We may thus fairly lay claim to have given to the commercial world the types of all the more important colouring matters of the present time. If, as is certainly the case, the development of these typical products has been allowed to take place in other countries, it behoves us, as a practical nation, to inquire closely into the cause of this success abroad, a success which will appear all the more remarkable when we bear in mind that we are the largest European producers of the raw material, gas tar, out of which the colours are manufactured, as well as being among the largest consumers of the dyes themselves. It is estimated that the amount of tar distilled annually in this country is about 500,000 tons, and it is certain that we distil at least one half of the whole amount of tar produced in Europe. The present state of affairs is that our competitors can afford to import the raw materials from us, to manufacture and return the colours so as to compete with us successfully in our own markets, and to undersell us in the foreign markets. The bare mention of these facts will be sufficient to indicate the existence of something requiring radical reform in our manufacturing system.

Before submitting to you the statistics of this industry which I have been able to collect, I think it desirable to make an attempt to show the inner mechanism by which chemical science has been and is being so successfully adjusted to commercial wants by our Continental neighbours. I regret exceedingly that my predecessors on this and other platforms have not left me the chance of giving a general sketch of the chemical development of the different groups of colouring matters. In fact, I find myself suffering here from several distinct disadvantages, but I hope, with your forbearance, to make the best of the situation. It will serve my purpose equally well, or perhaps even better, to confine my illustration to one particular group of colouring matters. The more striking achievements, such as the syntheses of alizarin and indigo, are now so familiar to chemical audiences, that their repetition would be unnecessary. Equally instructive, from the present point of view, would be the history of the colouring matters of the rosaniline group, and I can only express a passing regret that time will not permit me to recapitulate the steps in the beautiful series of investigations which led to the establishment of the structural formula of rosaniline and its derivatives by E. and O. Fischer, and then to the synthesis of these colours by Caro from ketone bases. The principle which I wish to bring out may seem a strange one to a "practical" people, but I am convinced that the whole secret of success abroad is the spirit of complete indifference to immediately successful results in which the researches are carried on. I say, "immediately successful," because it would of course be absurd on the part of an investigator not to take advantage of any discovery which happened to be of commercial value. But, as a general principle, the question of practical utility does not in the first place enter into the work. The great development of this and many other industries is mainly due to the complete and thorough recognition, on the part of our competitors, of the vital importance of chemical science. In this country, where the word "practical" threatens to become a reproach, we put science into the background, and attach all importance to the mere *technique* of our manufactures. If I might venture to offer an aphorism to the English manufacturer, it would be to the effect that he should look after the science, and leave the *technique* to take care of itself.

After these considerations, you will see that it is a matter of perfect indifference whether I take by way of illustration products which have been successful from a financial point of view or not. In order to give greater emphasis to the principle, I propose, however, to consider the history of some colouring matters which have found a market value, and I select this group with the more readiness because, on the one hand, it was not treated of last year by Dr. Perkin, and, on the other hand, it furnishes a splendid illustration of the way in which these coal-tar products are being scientifically developed in the foreign laboratories.

In 1863, Mr. E. C. Nicholson discovered a basic orange colouring matter among the bye-products formed during the manufacture of magenta by the arsenic acid process. The method of isolating this substance in a state of purity was very skilfully worked out by Messrs. Simpson, Maule, and Nicholson, and the colour was introduced into the market under the name of "phosphine." This dye was the first basic orange discovered, and the advantages which it possessed for certain kinds of dyeing enabled the manufacturers to sell it at a price which helped to cheapen the cost price of magenta to an appreciable extent. The chemical composition of the substance was established in 1863 by Hofmann, who assigned the formula $C_{20}H_{17}N_3 . H_2O$, and described the base under the name of chrysaniline. Although other and cheaper basic orange colouring matter have since been discovered, chrysaniline still finds a distinct use; and I am informed by Messrs. Brooke, Simpson, and Spiller that the amount of this colour now sold is not appreciably less than at the time of its introduction by their predecessors. The chemical constitution of chrysaniline remained unknown till about two years ago, when the problem was solved by O. Fischer ("Berichte," 1884, p. 203). In order to be able to follow the steps in the investigation, it will be necessary, in the first place, to go back to the discovery of another colouring matter, called flavaniline, of which the existence was made known by O. Fischer and C. Rudolph in 1882 ("Berichte," 1882, p. 1500). Flavaniline was produced by the action of dehydrating agents, such as zinc chloride, upon acetanilide, this fact having been observed by Rudolph in 1881, and the practical manufacture of the colour having been carried on under a patent by Messrs. Meister, Lucius and Brüning, of the Hoechst colour works.* Supplied with a large quantity of the pure crystalline material by the manufacturers, Messrs. Fischer and Rudolph established the formula of flavaniline, $C_{16}H_{14}N_2$, and showed that its formation from acetanilide might be expressed by the equation:—

$$2\,C_6H_5.NH.C_2H_3O - 2\,OH_2 = C_{16}H_{14}N_2$$

By the action of nitrous acid upon flavaniline a diazo-compound was produced which, by the usual method of decomposition by water, gave a phenolic derivative termed flavenol, and possessing the formula $C_{16}H_{12}N.OH$, thus proving that flavaniline contained a displaceable NH group. By heating flavenol with zinc dust, a base was obtained having the formula $C_{16}H_{13}N$, and termed flavoline. This base had an odour resembling that of quinoline, and all its properties suggested to the authors that flavaniline was in reality a quinoline derivative. That flavaniline was amido-flavoline was proved by nitrating the latter base, and reducing the nitro-compound, when flavaniline was obtained. In a later publication by Besthorn and Fischer (Berichte, 1883, p. 68) it was announced that flavenol, when oxidized by potassium permanganate in an alkaline solution, gave an acid which, on distilling with lime, furnished a base having all the characters of lepidine. By the continued oxidation of flavenol with excess of alkaline permanganate, another acid was obtained, which proved to be picoline-tricarbonic acid, and the latter, on further oxidation, gave picolinetetracarbonic acid ("Berichte," 1884, p. 2925).

So much for the facts; now for their interpretation. The production of flavenol from flavaniline by the diazo-reaction shows that the respective formulas of these substances are :—

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* I am indebted to this firm for having kindly supplied me with specimens of these products for exhibition.

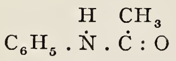
$C_{16}H_{12}(NH)_2N \qquad C_{16}H_{12}(OH)N$

Flavenol gave, as the first product of oxidation, lepidinecarbonic acid, of which the formula is $C_{10}H_8N(CO^2H)$ and by further oxidation it gave picolinetricarbonic acid, of which the formula is $C^6H_4N(CO_2H)_3$. Now the C-atoms oxidised by the breaking down of the 16-carbon atom flavenol into 11-carbon atom lepidinecarbonic acid, are those C-atoms which in flavenol are associated with the hydroxyl group, because this group is no longer contained in the product of oxidation. Thus the formulas of flavaniline, flavenol, and flavoline are better expressed as :—

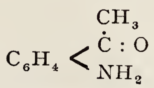
$$C_{10}H_8N.C_6H_4(NH_2)$$
$$C_{10}H_8N.C_6H_4(OH)$$
$$C_{10}H_8N.C_6H_5$$

From this it appears that flavanaline is amidophenyl-lepidine, flavenol hydroxyphenyl-lepidine, and that flavoline is phenyl-lepidine.

The central nucleus of flavaniline having thus been shown to be lepidine (which is methylquinoline), the next question to be settled was the mode of formation of the colour base from acetanilide. The authors suggest that at the high temperature of the reaction, acetanilide, in the first place, becomes transformed into the isomeric orthoamidoacetophenone :—

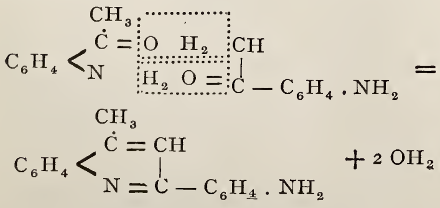

$C_6H_5 . \overset{H}{\dot{N}} . \overset{CH_3}{\dot{C}} : O$

Acetanilide.


$C_6H_4 < \begin{array}{l} \overset{CH_3}{\dot{C}} : O \\ NH_2 \end{array}$

Amidoacetophenone.

By the condensation of two molecules of the amidoacetophenone with the elimination of two molecules of water, flavaniline would be produced in a manner analogous to the formation of mesitylene by the condensation of three molecules of acetone under the influence of dehydrating agents :—


$$C_6H_4 < \begin{array}{l} \overset{CH_3}{\dot{C}} = O \quad H_2 \quad CH \\ N \qquad H_2 \quad O = C - C_6H_4 . NH_2 \end{array} = C_6H_4 < \begin{array}{l} \overset{CH_3}{\dot{C}} = CH \\ \qquad\quad | \\ N = C - C_6H_4 . NH_2 \end{array} + 2\,OH_2$$

The accuracy of this suggestion was verified by showing that orthoamidoacetophenone is present in small quantity when the reaction is arrested as soon as the formation of colouring matter commences; and conversely, when pure orthoamidoacetophenone was heated with zinc chloride, flavaniline was produced in small quantity.*

We may be permitted to pause at this stage of the investigation, before proceeding to consider the connection of this work with the constitution of chrysaniline. These results cannot but be regarded by chemists as a very beautiful piece of investigation; but the person of a "practical" turn of mind may possibly want to know what bearing they have upon the question of market value—the question which the manufacturer but too frequently considers as the only one of importance. Now it is the essence of chemical science—as indeed of all other sciences—that every discovered fact is related to other groups of facts, and although the relationship may not at once be apparent, it is only a matter of further development that is necessary in order to reveal relationships which are obscure on account of our imperfect knowledge. Thus, the policy of looking at a chemical product from the narrow point of view of immediate utility is not only unscientific, but it is detrimental to the interests of the manufacturer himself. Every new compound or process discovered—every structural formula established by legitimate investigation, may have an enormous influence, directly or indirectly, upon the market value of products at present sent into commerce. Our manufacturers must realise this if they wish to recover their position in the coal-tar industry, or in fact in any other chemical industry. There is no branch of manufacture so perfect as not to be open to further improvement, and until the broad spirit of scientific development is made to replace the suicidal policy of immediate utility, our position as a manufacturing nation is not likely to be improved.

In order to justify this digression by the particular instance now under consideration, we must return to the work of Messrs. Fischer and Besthorn. The discovery that flavaniline was a quinoline derivative was of importance as a principle, quite apart from any immediate value attaching to the dyestuff itself. Up to the time of this discovery, the quinoline derivatives had been practically of no importance in the tinctorial industries, but as a consequence of the present investigation, the question at once suggested itself whether the analogous bases of high boiling point, which are present in coal-tar, such, for example, as acridine, might not be utilised as sources of colouring matters. I may remind you that the fact of quinoline being an aromatic compound, was first established by the researches of our Chairman this evening, Professor Dewar, who obtained aniline from this base. In a subsequent paper on chrysaniline (O. Fischer and G. Körner, "Berichte," 1884, p. 203), it was pointed out that in the course of his investigations upon rosaniline Fischer had observed that the former base, like rosaniline, was capable of furnishing a diazo-compound. An observation made by Claus is also mentioned, viz., the conversion of chrysaniline into a phenol (chrysophenol) by heating to a high temperature with hydrochloric acid in accordance with the equation :—

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* Just after writing this paper, a new contribution to the chemistry of flavaniline was published by O. Fischer (Berichte, 1886, p. 1036) from which it appears that the condensation is really between one molecule of *ortho-* and one molecule of *para*-amidoacetophenone, the latter being produced by the isomeric transformation of the ortho-compound at the high temperature employed. The constitution of flavaniline is thus definitely established as para-amidophenyl-γ-lepidine.

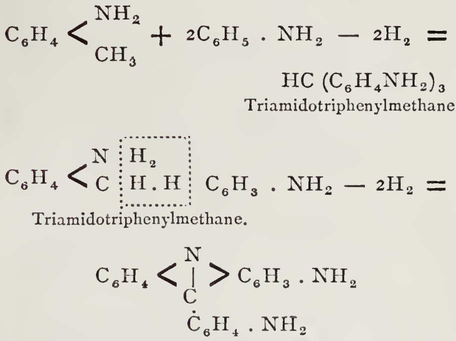
$$C_{16}H_{15}N_3 \,.\, HCl + H_2O = C_{19}H_{15}N_2O + NH_4Cl$$

Chrysaniline hydrochloride. Chrysophenol.

The investigation of flavaniline appears to have given an impetus to the ideas respecting chrysaniline, because of the general similarity in the properties of these two substances. In confirmation of this impression, it was found that by the oxidation of chrysophenol an acid was obtained which, on distillation with lime, gave a pyridine base. I need hardly remind you that picoline, which was obtained from the acid resulting from the extreme oxidation of flavenol, is methylpyridine. It was thus established that chrysaniline was a derivative of a quinoline base.

The next step in the investigation is a very important one. By decomposing the diazo-compound of chrysaniline with alcohol according to the Griess reaction, phenylacridine was obtained. Acridine is a base belonging to the quinoline series, having the formula $C_{13}H_9N$. It was discovered by Graebe and Caro in 1872 in crude anthracene. Phenylacridine accordingly possesses the formula $C_{13}H_8N \,.\, C_6H_5$; and chrysaniline appears as diamidophenylacridine — $C_{13}H_7(NH_2)N.C_6H_4(NH_2)$, because two amido groups are replaced by H by the diazo reaction. Thus the formula $C_{20}H_{17}N_3$ (first assigned by Hofmann to chrysaniline) is really the formula of the higher homologue, chrysotoluidine.

In order to explain the formation of chrysaniline during the oxidation of the materials (aniline and toluidine) in the "red melt" still, several suggestions were put forward, of which the most probable appeared to be that the base was derived from triamidotriphenylmethane, the latter compound resulting from the condensation of two molecules of aniline with one of orthotoluidine :—



$$C_6H_4 < \begin{smallmatrix} NH_2 \\ CH_3 \end{smallmatrix} + 2C_6H_5 \,.\, NH_2 - 2H_2 = HC\,(C_6H_4NH_2)_3$$

Triamidotriphenylmethane.

$$C_6H_4 < \begin{smallmatrix} N \\ C \end{smallmatrix} \boxed{\begin{smallmatrix} H_2 \\ H\,.\,H \end{smallmatrix}} \; C_6H_3 \,.\, NH_2 - 2H_2 =$$

Triamidotriphenylmethane.

$$C_6H_4 < \begin{smallmatrix} N \\ | \\ C \\ \dot{C}_6H_4 \,.\, NH_2 \end{smallmatrix} > C_6H_3 \,.\, NH_2$$

Diamidophenylacridine = Chrysaniline.

The relationship of chrysaniline to the colouring matters of the rosaniline group is thus indicated; but tempting as is this theme, time will not admit of further digression into this field. The main point, so far as we are at present concerned, is that by means of the present investigation, we have now arrived at a knowledge of the parent substance, acridine, of which a colouring matter more than twenty years old proves to be a derivative. By such results new fields of investigation are opened up, and direct methods for the production of chrysaniline suggest themselves. Even the practical requirements would be satisfied if it could be shown that the colour could be manufactured cheaply by a direct synthesis, instead of depending, as heretofore, upon the small and capricious secondary product of the magenta manufacture. As a matter of fact several syntheses of chrysaniline have been effected, one of which forms the subject of a patent (German Patent, 29142, April, 1884) by Messrs. Ewer and Pick, of Berlin. Into the mode of preparation by this patented process I cannot now enter any further than by merely stating that nitrodiphenylamine and nitrobenzoylchloride form the starting points, and that the specification bears the title—"preparation of chrysaniline and other colouring matters of the phenylacridine group." If an elaborate scientific investigation culminates in a patent, its utility will, I know, be conceded by many for whom the work would otherwise have possessed no particular interest.

The illustration which I have given is a typical example of the kind of scientific development which is being carried on by our chemical colleagues abroad, and which is being taken advantage of in the Continental factories. I do not wish to give you the impression that the particular colouring matters dealt with are of supreme importance industrially—they are of considerable importance, but the modern history of any other colouring matters would have been equally instructive. The beautiful researches of Bernthsen upon the constitution of methylene blue, would have done equally well had time permitted of my making use of them. It seemed to me more appropriate to this Section of the Society of Arts to give a somewhat detailed account of one particular series of investigations, rather than to take a skim over the mere surface of the enormous field which the coal-tar colour industry now offers. The case considered at any rate presents the advantage of not being too hackneyed, and this will be sufficient excuse for having made use of it.

It was stated at the commencement of this paper that there is reason to believe that our supremacy in the coal-tar colour industry has, for some years, been declining, and I have further expressed my belief that the chief cause of this falling off is the subordinate position given to chemical science in this country as compared with the status of this science abroad. Whether this explanation be accepted or not, the fact of the decadence of the manufacture remains, and I am in a position to bring this unpleasant truth home to our countrymen by a strong body of evidence. It must be borne in mind that the decline of any industry cannot be measured by the absolute weight of the products turned out annually, because the demand for the products in question may be on the increase, and we may be actually producing a greater weight of colours now than we were during our most successful period. The whole question is a relative one—it is simply how much material are we now turning out as compared with the amount produced by our competitors—what proportion of coal-tar products do we supply for our own and foreign consumption? In order to answer this question with some approach to numerical exactness, it occurred to me that the most trustworthy information could be obtained from the consumers themselves; and through the kindness of Mr. Robert Pullar, of Perth, and Mr. Ernest Hicksor, of Bradford, I have been enabled to put myself into communication with several of the representative dyeing and printing establishments of this country. The facts obtained, as showing the actual state of the industry at the present time, appear to me of sufficient interest to be given here in some detail. I may take the present opportunity of stating that my application for statistical information has been most courteously responded to by the various firms, to whom I have great pleasure in returning my thanks.

Edward Ripley and Son, of Bradford, perhaps the largest dyers of piece goods in the kingdom, inform me that during the year 1885 they used 86½ per cent. of foreign coal-tar colours, and 13½ per cent of English make.

Walter Walker and Son, of Dewsbury, dyers of wool for rugs, mats, carpet yarn, and blanket stripes, estimate that during 1885 they used 80 per cent. of German dyes. They state that the exact proportion is difficult to estimate, so that the figure given is only approximative. Referring to their larger consumption of foreign colour they state:—"It is very discouraging to have to do this and send the trade out of our country, but to our own interest and advantage we have to do it."

John Newton, silk dyer, Macclesfield. Mr. Walter Newton, F.C.S., informs me that during 1885 they used 80 per cent. of foreign colour. He adds:—"The rapid advancement in the improved manufacture of some of these dyes by the Germans is the only cause of our desertion from the English colour manufacturer."

G. W. Oldham, silk dyer, of Netherton, near Huddersfield, informs me that during 1885 he used 2,000 lbs. of German dyes, 1,100 lbs. of English dyes, and 800 lbs. of doubtful origin.

James Templeton and Co., of Glasgow, state that they dye as much as 30,000 lbs. of yarn (chiefly worsted) weekly, but they use only a small proportion of coal-tar dyes, all of which are of German manufacture.

Messrs. Leckie and MacGregor, of Paisley, inform me that in the west of Scotland, including Glasgow and Paisley, they are certain that at least 90 per cent. of the dyes used come from the Continent. Their own consumption of English colour only reached 6·8 per cent.

Alexander Harvey and Son, of Glasgow, yarn dyers, state that during 1885 they used 60 per cent. of German and 40 per cent. of English dyes. These figures do not include alizarin, of which they state that they used about equal quantities of German and English make. The English supply is chiefly made up of one article, "aniline salt." They add:—"We find the German makes in general of better value than the British, as our rule is, *ceteris paribus*, to give the home-make the preference."

Messrs. Manson and Henry, Glasgow, yarn dyers, state that they use only German dyes, adding that they find it to their advantage "for both cheapness and quality."

Among the largest consumers of coal-tar colours in this country are the jute dyers. As representing this department of the tinctorial industry, Messrs. James Stevenson, of Dundee, inform me that during 1885 they used only 7·7 per cent. of English colour. They have been good enough to supply the following analysis of their consumption:—

Scarlet	37	per cent., of which	nothing	is English.
Crimson...............	16	,,	6·4	,,
Blues	11·5	,,	nothing	,,
Oranges...............	11	,,	·05	,,
Greens	7	,,	nothing	,,
Magenta (residues)	6·5	,,	,,	,,
Maroon	5·5	,,	,,	,,
Pink	2·75	,,	,,	,,
Brown.................	1·25	,,	1·25	,,
Violet	1	,,	nothing	,,
Various	0·5	,,	,,	,,
	100 0		7·7	

Messrs. Cox Bros., of the Camperdown Jute Works, Lochee, state that practically the whole of the "aniline" colours used by them are of Continental manufacture.

With reference to the calico printers, the following facts have been collected:—

Messrs. Z. Heys and Sons, of Barrhead, state that during 1885, they used over 10,000 lbs. weight of colours (exclusive of alizarin) of which 700 lbs. only were of English make.

Messrs. James Black and Co., of Bonhill, Dumbartonshire, state that in their belief more than one-half of the colour used by calico printers is of foreign manufacture.

In the course of the present inquiry, it seemed desirable to obtain information concerning the consumption of alizarin, with reference to which the following statements have been received:—

Messrs. Walter Crum and Co., of Thornliebank, Glasgow, are of opinion that "the great bulk of what is used in this country is manufactured in Germany." They do not profess to be able to give actual figures having any approach to accuracy.

Mr. John Christie, of the Alexandria Turkey Red Works, Dumbartonshire (John Orr, Ewing, and Co.), states that they use only artificial alizarin in their establishment, their consumption being considerably over two million lbs. weight of 10 per cent. paste annually. Their consumption was in:—

1880..	98	per cent.	German	..	2	per cent.	English.
1881..	99	,,	,,	..	1	,,	,,
1882..	100	,,	,,	..	0	,,	,,
1883..	77	,,	,,	..	23	,,	,,
1884..	56	,,	,,	..	44	,,	,,
1885..	47	,,	,,	..	53	,,	,,

Messrs. William Stirling and Sons, of Glasgow, state that their relative consumption of English and German alizarin for Turkey red dyeing varies so much from year to year that they have no means of directly supplying useful data. This firm has, however, been good enough to make inquiries for me from a competent authority, who has furnished the following report:—

> "In 1883 and 1884, I estimate that the sales in the United Kingdom amounted to a monthly average of about 530 tons, 10 per cent. (say 6,360 tons, 10 per cent. per annum). Of this quantity, I estimate about 30-33 per cent. was manufactured in this country. Taking 1884 alone, the figures are estimated at 566 tons, 10 per cent. per month (say 6,800 tons, 10 per cent. per annum). Proportion manufactured in Great Britain, say about 30-35 per cent. In 1886, the consumption may be estimated at 550-600 tons, 10 per cent. per month (say, 6,900 tons, 10 per cent. per annum). Proportion manufactured in this country probably now very considerably more than 35 per cent."

This estimate of the total consumption (550 to 600 tons, 10 per cent. per month) is confirmed by my friend Mr. Thomas Royle, F.C.S., of the British Alizarin Company's works at Silvertown, but he is of opinion that 50 per cent. of this is of English manufacture.

By way of further confirmation, it appeared to me to be desirable to get the opinion of manufacturers themselves, and although this has been a matter of considerable difficulty, I am able to give some kind of an estimate. Mr. Ivan Levinstein, of Manchester, estimates that Germany produces:—

Colours derived from benzene and toluene, six times more than England.

Colours derived from naphthalene, seven times more than England.

Colours derived from anthracene, five times more than England.

The average production of Germany is thus about six times that of this country. Mr. W. A. Mitchell, of the firm of W. C. Barnes and

Co., Phœnix Works, Hackney-wick, informs me that of some 159 tons of "aniline" dyes which passed through their hands as agents last year, 95 per cent. were of Continental make. With reference to the two chief raw materials, benzene and aniline, this same firm estimates that about 75 per cent. of the whole quantity of these products made in England goes to the Continent.*

The facts and figures which I have now laid before you must be left to tell their own story—time will not permit me to attempt any analysis of them. The evidence collected will at any rate give a much more forcible idea of the true state of the coal-tar colour industry in this country than has hitherto been attempted, and if this evidence goes against us as a manufacturing nation, it is all the more desirable that our true position should be realised. I find that it is almost impossible to give a correct numerical expression in pounds sterling for the annual value of this industry to the country, as the estimates vary within very wide limits. According to Dr. Perkin, whose opinion on this matter will perhaps carry the greatest weight, the value of the annual output is between £3,000,000 and £4,000,000. That the industry is one of considerable importance on the Continent may be gathered from the official returns relating to the German exports. For the following figures I am indebted to Dr. H. Caro, of the "Badische Anilin and Soda Fabrik," Ludwigshafen on Rhine:—

Exported from Germany, from January 1st to December 31st, 1885.

Alizarin paste (? per cent.)	4,283 tons.
Aniline and intermediate products	1,713 ,,
Aniline, &c., colours	4,645 ,,

Dr. Caro adds that it is generally believed that about 4-5ths of the entire German production are exported.

The magnitude of this branch of chemical industry abroad will be gathered from the fact that a German factory of about the third magnitude consumes at the present time between 500 and 600 tons of aniline annually. According to information recently furnished to me from the two largest of the German factories, the Badische Company employ 2,500 working men and officials, and the Hoechst Colour Works (formerly Meister, Lucius and Brüning) 1,600 working men and fifty-four chemists. It must of course be borne in mind that in these factories the products are not "aniline" colours only, but alizarin, acids, alkalies, and all chemicals required in this branch of manufacture.

The industry which has been selected for this evening's topic is thus not only an important one in itself, but for us, as chemists, its development is fraught with meaning both scientifically and educationally. In taking up this subject it has not been my desire to exalt the coal-tar colour industry to a position of undue importance, nor do I wish it to be inferred that the remarks which I have made concerning its decadence, or at any rate stagnation, in this country are applicable to this manufacture only. The failure on our part to grasp the true spirit of chemical science in its relation to our manufactures makes itself felt in every industry in which chemistry is concerned. The strength of our competitors is in their laboratories, and not, as here, upon the exchanges. It is only by showing up our weakness in each industry that the state of affairs can be remedied, and our prestige as a manufacturing country restored. If each specialist would do for his industry what I have here attempted to do broadly for the coal-tar colour industry, we should get together a body of evidence which the Royal Commissioners on the depression of trade would do well to take into consideration. We have heard a great deal of late years about the subject of technical education, but the talk has been rather one-sided. We have had utterances from those who, recognising the enormous importance of this subject to the country, have munificently endowed those institutions for the promotion of technical education which are springing up around us; we have had all kinds of schemes from those who are taking upon themselves the duties of technical educators, but it appears to me that we have not heard with sufficient distinctness the voices of those who may be presumed to suffer most from the want of technical education, viz., the manufacturers themselves. I have heard rumours of the existence of a certain class of manufacturer—let us hope a rare species—who declares that science is no use to him, and that he can get along better without it. I must confess that I never met this individual in the flesh, but I know that he exists in some of our manufacturing centres. As a species he is, however, doomed to extinction in the struggle with his competitors, and we may consider him out of court in the discussion of schemes of technical education. It is now generally admitted that the days of empiricism have passed away, and most manufacturers admit that present success and future development depend upon a proper recognition of technical, *i.e.*, of applied science. But unless the manufacturers themselves speak loudly on this question, the voices of those who wish to promote scientific education may be drowned by the clamour of mere theorists.

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* According to a later estimate, kindly supplied by Mr. Ivan Levinstein, the quantity of benzene and toluene used in this country amounts to about half a million gallons, and that used in Germany to about two million gallons annually. About half the English production is, however, exported as aniline, toluidine, and aniline salt, while Germany converts into colouring matters at least 1,600,000 gallons of these hydrocarbons.

In no other department of our manufactures is the want of technical science more felt than in the chemical industries. We not only see this in the greater development of these industries abroad, but in some of our most successful factories here—and this applies more especially to the coal-tar colour industry—foreign chemists are employed, and as I have lately been informed by a well-known manufacturer, it is even impossible to get the necessary plant properly made in this country. There is no doubt that the recondite character of the truths of chemical science, as compared with the more obvious truths of mechanics and physics, has much to do with the want of popularity of this branch of knowledge, and is responsible for the circumstance that our science is regarded with comparative indifference until some branch of manufacture is *in extremis*. In our national characteristic of being "practical," we are apt to become short-sighted in our manufacturing policy, and to recognise only actualities to the exclusion of the potentiality conferred upon a nation by a broader scientific culture.

In conclusion, I have to express my thanks to Messrs. Brooke, Simpson, and Spiller; Messrs. Burt, Bolton, and Haywood; and to the British Alizarin Company for the fine series of specimens now exhibited. For the beautiful specimens illustrating the Continental manufacture, I am especially indebted to the Badische Anilin and Soda Fabrik, of Ludwigshafen on Rhine, and to the Hoechst Colour Works. The series of patterns dyed with known weights of fifty distinct coal-tar colours were prepared by Mr. Ivan Levinstein for the lecture recently delivered at the Royal Institution by Sir Henry Roscoe, to whom I am indebted for being able to show them on the present occasion.

DISCUSSION.

Mr. R. J. Friswell had listened with great pleasure to this paper, and from his experience, which now extended over some twelve years, in connection with the coal-tar industry, he could confirm every word which had been said. The great difficulty scientific men had to encounter was to persuade those whose money interest placed them at the head of large factories that scientific work, the practical outcome of which was not immediately visible, was really of value. It was a long struggle, but he thought they were beginning to see daylight at last. A feeling was beginning to be awakened, not in the coal-tar colour industry alone but in others also, and he thought the coming generation of manufacturers would take to heart the lesson which Professor Meldola and others had so strongly enforced, so that in the course of a few years a great change would be seen in this direction. What had been said with regard to the alizarine industry showed that already in that direction a very marked change was beginning to take place, and he hoped it would not be many years before they saw a change in the same direction in other coal-tar colours. Every Englishman must feel that it was a great reproach to this country that an industry which originated here should so far have slipped out of her grasp. They ought all to pull together, and endeavour by every means to regain the position once held.

The Chairman said this was a very recondite subject, and he desired most heartily to thank Professor Meldola for the very admirable manner in which he had brought it forward, and especially that he had not in any way feared to tell the whole truth. When such a statement came from a man who had not confined himself purely to the scientific side of the question, but who had had practical experience, who had been himself superior chemist in a large works, it showed that he was, from his thorough knowledge of both sides of the question, entitled to speak in this bold and straightforward way. He entirely sympathised with what had been said, because he had some considerable experience himself, but feared that he must differ with the writer of the paper on one point, where he said he had never met the manufacturer who declined to say that science was a great benefactor. On two occasions in his life he had certainly had this experience. At one time, when a young man, he was offered the same position that Professor Meldola held for several years, and the difficulty which arose was entirely with reference to supplying the laboratory. On another occasion a similar difficulty arose with a very distinguished man, in which he projected something of the same kind, but the moment he began to ask where the materials were, and where the laboratory was, the engagement was abruptly broken off, as this gentleman saw no reason for having a laboratory in connection with the work at all. There was the difference. It was not only the stimulus in the large German laboratories, where active research was going on, but it was the large stimulus now existent amongst the factories themselves. There the men were not isolated, but as they had heard there were something like fifty chemists in one large factory, so that there was a little scientific world in itself, where there was an incentive to continuous work. With reference to the question as to the want of popularity in chemical science, he admitted it of course, but the question was what was the full explanation of it. He thought it arose in a great degree from the want of encouragement of chemistry in the older universities. He said so not because the older universities sent out a larger number of men than the young ones, but simply because up to the present time they had no such thing as even a creditable chemical laboratory. Although he held the chair in one of these universities, he was always ashamed if anyone asked to see the chemical laboratory, because, in truth, there was none. It was in the same condition as it was a century ago. For the last year they had been endeavouring, in every possible way, to raise money to build a new laboratory. Of course the outside public imagined that the universities were rolling in wealth, when, in fact, they were in a state of absolute starvation. They could not get funds, all their borrowing powers were exhausted, and they were bonded to the last shilling to raise this new laboratory. It was this want of encouragement which was the great obstacle, and why was it? It was simply because the public could not understand why, if you built this new laboratory, if it were to cost so many thousands, and you had a grand palatial building, such as those to be found in Germany, what was to be done with it after it was built? They imagined that if you once put in the gas and a few glass retorts that was all that the chemist needed. That was a gross error; a chemist required a large annual grant to carry on researches, and all that went down the sink; but people like to see something for their money. They did not object to give a fine piece of apparatus for a physical laboratory, which would remain there for years with their name upon it on a brass plate; but if it was to go down the sink, they thought that could not be science. That was the explanation of the want of popularity. No doubt it was recondite, but the fact would be rather attractive to certain minds. The real difficulty was, that if once you got a pupil out of the mass who showed some originality, you found you could not entertain him, and had not the materials or the money, and consequently he went to some large German laboratory where material was to be had, and where his work was encouraged. As long as that went on how could the science be popular? Another important point was the proof here of the marvellous result of action and re-action. Of course, as a physical principle, that was admitted on all hands to be an elementary truth, but all these facts now brought forward had had the most remarkable effect as a stimulus on the growth of the more recondite scientific investigation; every new success connected with any colour which might be discovered was a stimulus to further investigation, and the result was that all the marvellous group of colouring matters were now to be had in such enormous quantity that the chemist got numerous new foci from which to start fresh investigations. Consequently all this industry had conversely affected chemical laboratories, purely scientific, by the supply of splendid new material. In conclusion, he begged to propose a hearty vote of thanks to Professor Meldola for the paper he had given.

Mr. LIGGINS asked leave to second the motion, in order to make a few remarks from a somewhat different point of view. It was impossible to overestimate the brilliancy and beauty of these coal-tar dyes, or to give too much praise to those chemists who had invented the processes which had given such brilliant results, and as an artist he must say it was impossible, either with oil or water-colour, to even produce colours of such beautiful shades as some of those which were exhibited; but there were two sides to every question, and several times within the last few weeks the most thorough condemnation of aniline dyes had been pronounced in that room by able men and scientific men, especially in connection with the artistic work of Japan and Hindostan. The carpets of India were said to be ruined by aniline colours which were used in dyeing, and it was said to be one of the greatest misfortunes for India that these colours had been introduced, as they were very inferior to those the natives had been for centuries in the habit of using; besides that, it was very commonly supposed that the colouring matters of various articles of clothing were poisonous. A lady he knew had lately been laid up from being poisoned in the feet with what was said to be a magenta colour, and he recollected when there was a long controversy in the *Times* upon this subject. It was no doubt the fact that many of these colours were very fleeting, and, therefore, were unsuitable for expensive fabrics, such as carpets and drapery for decoration, although suited for dresses which were used for a short time, and then thrown aside.

The motion having been carried unanimously,

Professor MELDOLA said he was perfectly aware of the state of chemistry in the University of Cambridge, but his respect for the Chairman compelled him to suppress rather more than he should have done had he known the Jacksonian Professor was going to make a clean breast of the situation. With regard to the fugitiveness of these colours, there was a great deal of misapprehension, and the same with regard to the poisonous character of the dyes. A great controversy had been carried on lately in Bradford before the Society of Dyers and Colourists. Specimens had been submitted to careful analysis, in order to detect arsenic, because it was known that some of these colours were made by means of arsenic acid, and it was thought they might retain traces which rendered them poisonous; but the amount found was infinitesimal, and he had not the slightest hesitation in saying that it would not do harm to eat a considerable quantity in an undiluted state. There was not more arsenic in well purified magenta than could be got out of an average glass of Thames water. No doubt many of these colours were fugitive, but, on the other hand, there were bad dyers. In a great many fabrics he had seen, the colour had come off simply because they had been badly dyed; there was no fault in the colouring matter, but in the method of application. With regard to carpet yarns, some of the fastest which existed were shown on the walls, some of these alizarine colours, which were used for dyeing carpet yarn, would bear exposure to light, and remain unaltered long after the old vegetable colours had faded completely away.

INDIAN SECTION.

Friday, May 21, 1886; Colonel YULE, C.B., in the chair.

The paper read was—

EVERYDAY LIFE OF INDIAN WOMEN.

By CAPT. RICHARD CARNAC TEMPLE.

To those of my hearers who are practically acquainted with India, the title of this paper may sound misleading. At any rate, it may be objected that it is quite impossible to deal with so vast and varied a subject as the feminine daily life of the very heterogeneous peoples which go to make up the 250,000,000 of the Indian population, in so short a time as that at my disposal. I am, of course, aware that one of the chief characteristics of Indian domestic polity is extreme subdivision, and that the tendency among all classes of the natives of India is towards the social isolation of groups with contracted interests, and the consequent accentuation of minute differences in habits of life. The results of this are what is generally known as "caste," and it is caste that underlies and controls all social matters that are peculiarly Indian. At first sight, therefore, under these circumstances, there can be no such thing as a common method of life among the women of a population which is an ill-assorted compost of wild and savage tribes of diverse origin; of Brahmans and orthodox Hindus; of heterodox Hindus and Brahmanists by conviction and birth; of Buddhists, and Jains, and Parsis; of Muhammadans, and Jews, and Christians of long standing; of Aryan and Dravidian races; of aboriginal clans of Aryan and non-Aryan descent; of highly cultivated communities and completely ignorant tribes; of whole peoples within and without the pale of Oriental civilisation. But, nevertheless, there exists a standard of life which is Indian, and to which all the varieties of the natives of India are drawn—just as there is a life which is Oriental in the usually restricted sense of that term, habits that are Indo-Chinese, and manners that are European. No one supposes that Norwegian and Italian ladies live exactly in the same way, or that English and Spanish women adopt precisely the same mode of life; but that there is a general line of conduct which is common to all European countries is apparent to every one who observes mankind. So it is in India. And the overshadowing influence to which every true native of the great peninsula unknowingly submits is that wielded by the modern Brahmans through their staunch henchmen, the high-caste Hindus. In describing, therefore, in very general terms, the aims and habits of an ordinary Brahmani, one can give a fair notion of a life to which every Indian woman, however antagonistic her creed and race, is unconsciously led on by instinct, as it were, to imitate, and which is her invariable model.

Habits of life are enormously, if not mainly, influenced by religion, and this leads me to say a few words here regarding Brahmanism as a living and active faith, though it has been the fashion in certain authoritative quarters to look on it as dying, if not already dead. Granting that it is not a proselytising, in the sense of being a missionary, religion, and granting that its fundamental theory—it is only a theory and not a practice be it remembered—is, to parody a well-known saying, that *Hindu nascitur non fit*, still there can be no doubt that it manages to make more converts by mere assimilation than can any other religion in India by direct missionary effort. This absorption into Brahmanism is becoming, under the *pax Britannica*, day by day, a more important feature in Indian social economy. As surely as the English bring fresh uncultured tribes under their civilising influence, so surely do they add to the number of the Hindus; as surely as the iron hand of Anglo-Indian law, by refusing to recognise any difference between man and man, causes the upward rise in the social scale of those that labour to good purpose, so surely is the cause of Brahmanic orthodoxy advanced and its influence widened. I have watched the first process myself in the case of the recruits to our little army of Gurkhas; the wild mountain boy, on joining his regiment, is taught not only his drill, but also the Hindustani language as understood in military circles, and with it his religion, *i.e.*, a smattering of current Hinduism. The second can be seen in progress any day all over India, by anyone who will take the trouble to observe the career of a successful handicraftsman, or small trader. At first an "outcaste," dealing only in matters of religion with his tribal soothsayer; as he gathers money, he sets up a Brahman priest, and minds the orthodox gods, and at last, when respectable and wealthy, he develops into a full-blown Hindu; and then, since in all Hinduism ceremonial orthodoxy is synonymous with social respectability, he adopts Hindu manners to the full; isolates his women, prohibits the re-marriage of widows, marries off his infant children in the proper quarters, and practises the thousand and one customs peculiar to his adopted religion. Of course, in order to be able to thus attract to itself so many antagonistic principles of custom and belief, the modern Brahmanism can have no hard and fast creed. It has, in fact, *no* creed at all, properly so called. Nothing in the shape of "I believe in God the Father Almighty;" nothing like the strict Muhammadan formula—*lá iláha ill'illáhu, Muhammadi-'r-Rasúlu'-lláhu* (there is no God but God, Muhammad is the Prophet of God). It consists rather of a leading principle, viz., to gather together whatever items of belief may come to hand, in order to develop them in a certain definite direction, under the control of its own priests, and for their benefit; and while the process of development is going on, it naturally engrafts its own customs on to those it already finds in existence. Herein lies its wonderful vitality and strength, its capacity for digesting anything that it gets into its maw, and its power of resisting internal disruption. The apparently elastic network of caste and family customs that it invariably twines round its victims is marvellously cruel, and so unendurable that revolt after revolt has been made against it; but the result, so far, has been only to loosen the meshes for a time. Slowly and surely the intangible threads have tightened again, as by degrees the very customs created by the schismatics are adopted by its priests, and made to conform to the general theory—all the harder to resist because it is never formulated. The mighty rebellion of Guru Nanak may be said to have already collapsed, for though the Sikhs are still to be numbered by the million, Brahman priests now habitually control those domestic ceremonies from which the schism was mainly intended to exclude them. The Raidasi Chamars still, perhaps, keep themselves separate, but signs are not wanting to show that they, too, will go whither have long gone the Kabirpanthis and the free-thinking followers of Tuka Ram and Namdev. Again, the bulk of the Muhammadans of India, being descendants of tribes converted wholesale in various ways to Islam in days gone by, are still Hindus in many matters of thought and custom. In fact, if we extract the profession of faith and a few formulæ, it is not at all easy to say, as regards them, where Islam begins and Hinduism ends; in any case Brahmanism overshadows their lives. The Jains, at least that important section of them known as the Saraogis, are separated from Hindus proper rather in sentiment than in fact; and though the Parsis, Jews, and Christians, have greater powers of resistance, yet it would not be difficult to show how greatly the all-pervading faith of Hindustan has influenced them too. Many a missionary could tell a tale of more or less ineffectual battle against the notion of the existence of a Christian "caste." Of course, I am not now speaking of the tenets deliberately held by the authorised exponents of the several rival creeds, but of the religious ideas of the unintelligent masses, which are to my mind—and here I find myself in accord with the best credited observers of Indian life—the outcome of an unthinking reverence for things usually held to be holy, *i.e.*, hagiolatry, whatever be the outward expression of faith. Of such a state of things Brahmanism is pre-eminently adapted to take full advantage, for it presents no bold front to prejudices, and bends no man to its will, but rather puts forth its tender tentacles, gradually draws to itself, and quietly absorbs all things.

As my opening sentences will have shown you, I would not have it inferred from what has been just said that I hold all the women o India to lead practically identical lives; that the secluded banker's daughter has much in common with the scavenger's wife, free to go where she pleases and to speak to whom she will; or that the worthy spouse of the village Maulavi would not at once flare up and feel highly insulted if told that her life was conducted on much the same lines as that of the Panditani over the way. It would be more than erroneous, moreover, to state that a woman of Kumaun has exactly the same views of propriety as she of Mahabaleshwar, or that the grimy Panjabi has manners similar to the oiled and carefully bathed inhabitant of Madras. All I wish to assert is that a special way of living underlies all those differences which appear so great to the casual observer, and that beneath the chance-tossed waves on the surface there lie hidden depths of female life which are distinctly Indian, and which can be best sounded by a study of the high-caste Hindu women. The Brahmani is, as it were, the fashionable beauty, whom all of her sex in India follow, each in her own way, and with the varying success with which maids copy their mistresses all over the world.

Enough has been said already to satisfy you that I cannot on the present occasion enter into the details of the life of orthodox Hindu women. Nothing more, indeed, can be done now than to indicate its merest outlines in order to show of what it mainly consists, whither it tends, and how it affects those that lead it. In endeavouring to go through the task I have been invited to undertake to-night, I am bound to plead that, as an Englishman, I cannot do more than speak under correction. Hindu exclusiveness, as you all know, absolutely prohibits outsiders from personally observing what I am about to describe, and all that can possibly be done by persons such as I, is to procure our facts as nearly at first hand as practicable. Hence the necessity of explaining briefly what the sources of my information are. Chiefly, then, I have drawn upon matters which have come to me as the first hearer of the tale; partly because I am quite sure that all the facts thus learnt are straight from the mouths of trustworthy natives of India, and partly because I should be sorry to be, by any mishap, a misinterpreter of other people's writings. Although I shall not to-night be wittingly guided by any of them, there are several works of original information, more or less directly bearing on my subject, which all who are interested in it would do well to study. Among these are "Hindus as they are," written, indeed, by a Christian convert with something of the convert's proverbial asperity towards the followers of the religion he has discarded, but containing much that is valuable to the student; "The Hindu Family" of Balram Malik, a far superior work to the last, by the well-known Judge of the Calcutta Small Cause Court, who has treated his subject as only he can, that is in full sympathy with it, and, of course, with complete knowledge; and "The Life of a Hindu Woman," by the celebrated Brahmani Ramabai, who was driven to Christianity at last by the persecution of her co-religionists. This latter is a mere paper hidden away in the "Cheltenham Ladies' College Magazine," and there is not much of it, but naturally, as far as it goes, it contains the confessions of one who has herself been through the mill. For Muhammadans, there are Dr. Herklot's "Quanoon-e-Islam" and "Notes on the Indian Musalmans," by the wife of Mir Ali Hasan, who was an Englishwoman. And then there are several collections of folk songs,—notably Gover's from Southern India, and Grierson's from the North—which, between the lines, contain facts about Indian women that none can gainsay. However, I shall now confine myself to statements based, firstly, on notes supplied me by natives for "Panjab Notes and Queries," which I have edited from the commencement; secondly, to the late Dr. Fallon's splendid collection of "Hindustani Proverbs," 12,500 in number, which I commenced editing and translating in 1883—a work still in progress; and, thirdly, to the various collections of folk songs I have made and published at different times within the last eight years.

There are, of course, several ways in which the female life of India can be viewed. For instance, it can be looked at from a high moral standpoint of the European sort, or an instructive lesson in religion, as understood by us, might be taught from it with our dusky Indian sisters as the "dreadful examples." Anything of this kind is, however, far from my present purpose. My aim is rather to try and grasp, without unduly criticising it, what that life must really be, and in roughly describing it, to bring it home to your minds; and though I shall touch upon matters and notice conditions which are very foreign and even shocking to our ideas, I shall not mention them for any other reason than that they are facts which cannot be blinked.

Domestic manners are everywhere composed of the same elements, if we eliminate from our daily life the occurrences dependent on chance, and those circumstances which, even if recurrent, are in reality occasional. All the world, in fact, sings the same tune, though each community has its own pet variation. Every family is bound to evolve a *modus vivendi*: it cannot help making rules of conduct for eating, and drinking, and sleeping, for work, and intercourse, and recreation, as these are matters that, happen what may, must be attended to every day of our lives. Accordingly, wherever we go, we find regulations upon all these things, and the point we have now to consider is what the ideas of household economy are, which dominate in a general way the domestic laws of the most orthodox of the Hindus, and through them the whole of the Indian communities, and then how they affect the women subjected to them.

An Indian woman's life in its ordinary course is divided into two clearly defined parts, which are quite distinct, though separated from each other only by the fateful day on which she first goes to take up her abode within her father-in-law's family. Note that it is not called in the Indian languages her husband's family, for that, under the Indian family system, it can seldom be in the case of a bride. Childhood rather than girlhood is the heyday of the Indian woman. Free to play as she pleases, with plenty of companions, for children galore can hardly ever be wanting in a family which all live together, from oldest to youngest; free to run in and out of the houses of friends, never bothered to learn anything except what she can pick up from the women about her, never worried with caste restrictions, never asked to do more in the way of labour than to help in the housework, petted by her parents, spoilt by her aunts and uncles, and beloved by her brothers, an Indian girl-child is indeed happy—as children count happiness. And then suddenly the curtain falls. At about ten years of age—earlier in some parts and later in others—our spoilt child is old enough to work in earnest, and so she is packed off, sorely against her will, to join her husband's family, entering it not as our brides enter their future homes, at the head of the female community, but at the bottom. Child though she still is, her childhood is now for ever past, and she is turned into a young woman, only too often into by no means a happy one.

At this stage it is necessary to consider two matters, so far as they affect an Indian bride, viz., the practice of infant marriage, and what is known as the joint-family. I need hardly state that the so-called "marriage" of infants is practised among all classes in every part of India, though of course there are many exceptions to the rule. The term "marriage," as applied to this ceremony by us, is, however, rather misleading. It is in reality an irrevocable betrothal—a bargain not between the infants who are "married," but between those who control them, being often nothing else than a purely commercial contract. It arises out of the theory that a woman is for life under tutelage, and her "marriage" is, therefore, merely a transfer of the right over her to another party, a transfer naturally very frequently made in return for a pecuniary consideration. After this marriage or betrothal, the girl usually remains with her parents, in trust for those to whom she is to be transferred, until the home-coming or going to her husband's house, which may be looked upon as the real marriage, as we Europeans use the word. Until the second ceremony takes place the child-wife is still a child to all intents and purposes, and treated as such, and it is only after it that she in any sense enters on the duties of female life. The family she joins is exactly like that she has left, only it is that of another; to her a vast difference, and one which she never forgets—indeed, it is not unfrequently made painfully apparent to her at every step. What I may call the regulation Indian joint-family is one composed of the paterfamilias, all his sons and brothers, and various extraneous relatives, such as nephews, cousins, and wife's kindred, for the male part; and all their wives, in addition to his own wife and daughters, together with a sprinkling of the family widows for the female part. In this patriarchy there are grades upon grades, both male and female, dependent chiefly upon age and distance by blood from the head of the family; and as everybody is married in India as soon as the time for it comes, the chances are that the last-made bride is, in the nature of things, in the very lowest place.

In the average Indian family the strictest domestic economy is the rule of life, and the household work is done by the women of the household, not, as with us, by paid servants. Servants there are, of course, in all Indian families, but they are, as a rule, on a totally different footing to the European domestic, being for the most part independent persons with a *clientelle*, for whom they perform certain customary services for a customary wage. The distribution of the daily work, down to that of the most menial kind, lies with the materfamilias, who may be best described as the oldest woman in the family proper under coverture, for widows can have no authority. The cooking, as the work of honour, she keeps to herself, but the house-cleaning, the washing, the care of the children, the drawing of the water, the making of the beds, and so on, is done by the less dignified members of the household, as she directs; and whatever is most menial, most disagreeable, and the hardest work, is thrust upon the bride. She is the servant of the very servants, and must obey everybody. It is hardly, therefore, to be wondered at that, after her previous training, it is by no means an uncommon occurrence that she has to be forcibly broken into her new way of life, that she is for ever sighing after the flesh-pots of her father's house, that there are various "customs" which enable her to revisit it at stated times after the marriage, and that the law is often invoked to oblige brides to return to their husband's families after the customary term of such visits has expired.

Not only is our bride thus turned into a drudge, often unmercifully overworked, but from the day she gives up her childhood to the day of her death—it may be for sixty years—she is secluded, and sees nothing of the world outside the walls of the family enclosure. It should always, therefore, be borne in mind when trying to realise Indian female life, what a very important thing the domestic economy is to a woman; how largely the petty affairs of the household loom upon her horizon. Her happiness or misery indeed entirely depend on the manner in which the affairs of the family are conducted. Now, considering that the female mind has for centuries been mainly directed to this all important matter, it is not astonishing to find that such questions as the proper method of eating and drinking, and of domestic propriety generally—the intercourse, that is, which is permissible and right between the various members of the household, male and female—have long been regulated with the utmost minuteness. To us who roam the world at will, and whose interests are often fixed far more outside than inside our homes, it may seem remarkable that such infinitesimal restrictions and numberless customs as are found in full swing in an orthodox Hindu household should be remembered and carried out with the exactitude demanded of the womenkind; but if we consider that these make up their whole life, and that they are called upon to pay attention to nothing else, their capacity for recollecting when to veil and unveil, whom to address and avoid, when they must run away, and when they may speak, ceases to be extraordinary. And regarding these customs of social propriety, I must say that the more one studies them the more one is impressed with their perverted ingenuity. They seem purposely invented to make the unfortunate victim of them as uncomfortable as possible. The Indian woman, isolated from the outer world by custom, is again by custom isolated as far as practicable from all the male members of that little inner world to which she is confined. Free intercourse, even with her own husband, is not permitted her while yet her youthful capabilities for joyousness exist. No wonder then that absence of jollity is a characteristic of the Indians generally, for the happy laughter of a home is denied them by custom in the most persistent manner. I cannot go into all, or nearly all, the customs by which the orthodox Brahmanists have succeeded in rendering themselves a sombre people incapable of seeing a good-natured joke, and whose young men and maidens never laugh for laughter's sake. A few will suffice to bring home to you how completely the women are in sympathies and life separated from the men, and how the members of the sexes again are far from mixing freely with each other. Very small is the world within the four walls of an Indian house, and it is really pitiable to see how greatly it is divided within itself.

Every person belonging to the European races, an Englishman especially, well knows how much common meals tend to social sympathy; how powerful a factor they are in promoting pleasurable family existence, and in educating the young to good manners. There is nothing of this sort in Indian upper class society. There the men and women dine strictly apart, the women greatly on the leavings of the men, and that, too, in messes of degree, very like those in a royal naval ship. Paterfamilias dines by himself, then the other men together in groups, according to standing, waited on by the women under fixed rules; and lastly the women, when the men have done, our poor young bride coming last of all, obliged often to be content, I need hardly tell you, with the roughest of the fare. In the British Navy separate dining was adopted for strong reasons of discipline; in an Indian family it is the rule of life to which all are subjected alike.

Such, then, is one of those customs which go to make an Indian woman's existence less happy than it might be. Let me tell you another, this time as to family intercourse. The rule may be roughly stated thus. No imported woman may have any relations with those males who are her seniors. Every bride is such an imported woman, and all the household which she enters, who are the seniors of her husband, are her seniors. This at first generally includes nearly the whole family, and must necessarily for a long while include the major part of it. In all her life she never speaks to her husband's father, uncles, or elder brothers, though dwelling under the same roof, or, to speak more correctly, within the same enclosure, for an Indian house is what we should call a courtyard surrounded by sets of apartments. On the other hand, paterfamilias has not only never spoken to, but technically never even seen, by any of the younger women of his varied household, except those born within it, though they all dwell under his protection and at his expense. You will perceive, therefore, that the women's lives are contracted to within even a smaller sphere than that limited by the boundaries of the common family dwelling.

What would seem to us to be intolerable restrictions by no means end here. In many places it is not proper for a young father to fondle his own children in the presence of his parents, and highly improper for a wife to be seen holding converse, or appearing unveiled, or sitting down before her own husband, until she has become a mother. It is hard for us to realise how artificially lonely a life hedged about in this way must be, and how it must affect the temperament. Native writers tell us that breaking the spirits of the brides is looked upon by materfamilias as an essential part of education. Who can wonder at it!

There is another custom regarding which it is useless to pretend that it does not lead to endless misery and family squabbling—the absolute subjugation of the women to the materfamilias. The mother-in-law is indeed an awful personage in the eyes of her sons' wives, one against whose will and caprice it is hopeless to rebel. I can hardly describe her power better than by noticing a daily ceremony which symbolises it. It really amounts to wishing "good morning," is called in Upper India *máthá tekná*, and consists of bowing down to the ground and touching it with the forehead. All the women, except her own daughters, perform it daily to the materfamilias when they first see her, and a bride must do it practically to everybody.

An Indian woman's happiness in life immensely depends on her becoming the mother of a son. This at once raises her in the family estimation, which is all in all to her; insures her against the greatest bitterness of widowhood, in case that befall her; and procures her domestic authority should she survive to mature years under coverture. Materfamilias is a veritable queen in her own little world, often coercing her husband, commanding her sons, and ruling the rest as she pleases. From what has come under my observation, I have long felt assured that, speak contemptuously of the opposite sex as they choose, lock them up as they may, and treat them as mere breeders of sons as they will, the natives of India are far more henpecked than they care to admit. Outside their homes the men live a life of their own, untrammelled by considerations of the fair sex; within them they have little control, and it must be borne in mind that it is the women that have come to be such sticklers for the continuance of the state of things I have above endeavoured to describe. The remarks just made apply, as above said, to the mothers of sons only. Should a woman be so unfortunate as not merely to be barren, but to be simply the mother of daughters, life goes much harder with her, especially as this is so liable to bring upon her that which (if their songs and sayings are to be trusted) the Indian women dread more than all things except widowhood—the advent of the co-wife. There are proverbs innumerable to show how very badly co-wives get on, but "a fairy for a co-wife is a devil," exhibits the mutual relation forcibly and clearly as it usually is. And when the rival wife brings forth the long-desired son, the barren woman's cup of bitterness is full, and all her hatred towards him is, to those who know the circumstances, well expressed in that most sarcastic of sayings in any language, "The son of the co-wife." No more words are wanting to the Indians to convey the expression of all uncharitableness, and indeed even the kindliest of them will admit that among them women and their step-children never do hit it off.

As to the hard lot of the childless widow, so much has been said elsewhere, and so often, that I do not feel inclined to enlarge upon it to-night, especially as enforced widowhood is not nearly so general as is usually made out by those, who would deduce a moral from Indian manners to the glorification of the habits of Christians. It is often not prevalent among classes who conform generally to the customs I have been mentioning, and circumstances make it impossible among many that are not comparatively wealthy; but where it is the rule nothing can be more cruel, and, I feel justified in using the strong term, more revolting. Take the case of the widow from infancy: shorn of all that women valu anywhere in the world, dressed in coarse clothing, deprived of her ornaments, compelled to fast till health breaks down, made to subsist on the coarsest of food, kept out of what amusements come in the way of the rest of the household, forced into being the unpaid drudge of the family, held to be the legitimate butt of the ill-nature of all, considered fit only to amuse the children, openly called and taught to think herself a creature of ill-omen —this being the cause of all the rest of her sorrows—superstition has indeed nowhere else shown more clearly its power to pervert the reason of man. How much the women dread widowhood is exhibited to the full in the fact that to call a woman a widow is to offer her a dire insult, and from her earliest childhood a girl is taught to pray that she may die while yet the red spot of coverture remains on her forehead. In any case the fear of widowhood overshadows the Hindu lady's life, even though she hate her lord; just as it has often seemed to me that the picture of the death in front of them must always be before the minds of the orthodox Bengalis. We all know how dearly cherished is the idea of a death with loving hands about us to soothe our pains, and the sound of loving words to comfort our last thoughts; well, what has the Bengali before him? As soon as he is pronounced incurable, rightly or wrongly, by the local quack, he is carried, still living, out of his house, amid the screams of his widow to be and the wails of his kindred, down to a river or pond to die, and there in all his misery kept half immersed, whatever be the weather, until death releases him, it may not be for days. I do not know how it strikes those who must expect it as their most probable end, but the vision of that last agonising journey and the pain and suffering of it, the view of that muddy bank and the darksome water and the horror of it, would be ever before my eyes were I in such a position.

However, it is no part of my business tonight to tell a sensational tale, nor do I wish to convey an impression that an Indian woman's life is necessarily all unhappiness. Human nature in her case is as capable of adapting itself to circumstances as elsewhere, and since the ultimate gauge of permanent individual happiness is suitability of temperament to immediate surroundings, many a woman in India must be so constituted as to be quite content with the life she is called upon to lead, and in fact to enjoy it. When a girl is naturally sedate, yielding, and good-natured, of blunt susceptibilities, limited aspirations, and strong religious emotions, she will give into her mother-in-law, avoid quarelling without effort, follow the course of life laid down for her without demur, thoroughly believe it to be the only desirable life to lead, find the innumerable restrictions imposed upon her not unwelcome, and become contented with her contracted sphere; and, if those about her happen to be kind, be quite as happy as any girl in the world. But the potentialities for misery involved in her surroundings are enormous, and where such is the case, to argue that misery is not the frequent result would be to argue against human nature. At all events the purview of her life is limited to a degree which it is difficult for us to realise. It resolves itself daily into this: the strict performance of petty religious ceremonies, feeding, bathing, dressing, cooking, and household drudgery, all so hedged round with minute regulations as to make each a special occupation, and to these must be added visiting and gossip during her afternoon leisure. How petty that gossip must be can be inferred from the facts already laid before you. Remember that the great majority of these ladies are all together uneducated, that ever since they have been old enough to observe and think they have been shut out from the world, that they have no knowledge of any person or thing beyond those immediately around them except what they can pick up from their menials, and then you will have no difficulty in understanding that their interests are centred in their jewels and ornaments, their food, their personal concerns and troubles, the peculiarities of the members of their households, and lastly and chiefly, in what social ceremonies and feasts happen to come their way, the widows being shut out from even these. If a marriage, a death, or a birth among their kindred were the only landmarks in English ladies' lives, we should soon have these occasions erected into as lengthy family ceremonies as they are in India. If the observance of Ash Wednesday, Shrove Tuesday, Candlemas, Michaelmas, Lady-day, May-day, and what not of our standard religious and secular feasts were the main opportunities for breaking the monotony of an imprisoned life, how carefully they would be kept, and how anxiously looked forward to. This is why all the innumerable *shankrânts*, *ekâdshís*, *ashthamís*, *náumís*, and other queer fasts and feasts are so regularly attended to in India. Indeed, female ingenuity has there long ago seized upon the many other opportunities for diversion afforded by occurrences incidental to human existence, and there are ceremonies to be gone through on every possible excuse. No phase of life escapes—childhood, puberty, pregnancy, maternity, widowhood, all come in for a share. The first tying of a rag round a boy's loins occasions a family feast, and so does the first time his hair is cut, the first time he puts on the *janéu*, or sign of caste; and so on all through life. Before he is a man he has gone through sixteen sacraments, each a notable occasion in the eyes of his women folk. Babies are put through all sorts of ceremonies, on the first, the fifth, the seventh, the fortieth, and other days after birth. They cannot even see the sun for the first time, and, of course, cannot be given a name, without a feast being held over the fact. As to the women's special ceremonies, they are just as numerous, and, though before a mixed audience I am here treading on delicate ground, it would be giving an incomplete picture of the native woman if all allusion to them were avoided. Of their tenor and effect I shall, however, have probably said enough in telling you that many of them are meant to give prominence to domestic occurrences of such a nature as to render innocence impossible to an Indian girl.

I must ask your leave here to digress a moment into controversial regions, and to comment on a matter regarding which interested natives and imperfectly informed Europeans are fond of throwing much undeserved blame on the Anglo-Indians, and that is, as to their not mixing socially with the natives. Especially is this reproach levelled at the English ladies, whose lot is cast in India. Now there are two sides to this question, and I will take that one on which, as a close and long observer of Indian character and habits, I have formed a strong opinion; and I will say at once that this charge, though plausible, is very unfair. Granting that coldness is the besetting sin of the English, our manners are effusiveness itself when compared with those of the Indians. How, I ask, are we to be socially friendly with a people who will not eat or drink with us? To offer to whom such a simple and natural kindness as a cup of water to quench thirst, or, it may be, to alleviate pain, is an offence against religious feelings? To be on terms of friendliness or of mutual respect is, even under these circumstances, easy, and I may say that such relations are common enough in India; but is it possible for true sociability to exist? It is not making use of exaggeration to say that it does not obtain between natives themselves, unless they happen to be of the same caste. Again, all the world over, to admit a man to the society of wife and children is to acknowledge inferiority, unless such courtesy is mutual; and does not the Englishman in India know full well that if he introduce a native to his home the compliment will never be returned? I will go further, and say that to refuse food at another man's hands as being polluted by contact with him, is to place him in an inferior position. It is all very well to assert that the native is bound to act with this insulting incivility by his religious customs, but every nationality must reasonably take the consequences of any peculiarities of custom it chooses to adopt, and the Indian cannot fairly blame the Englishman for thinking that proper self-respect makes it impossible for him to hold familiar intercourse with those that cannot allow social equality. The fact is, the European who knows the country will not stand the galling claim to racial superiority conveyed in Indian manners, and while these remain what they are, he will hold aloof from those who practice them. This is natural, and though religious susceptibilities have undoubtedly a strong claim to consideration, human nature has a claim that will not brook being passed over. The argument that superior civilisation should cause the English to sink their feelings, can be met by the more cogent and practical one, that where masses of people are concerned, nature will always keep the upper hand, with the result in this case that so long as the Indian's ways continue to be offensive, the masterful Englishman will resent them. It may be said, however, that women are not excluded from Indian harems, and that if the Anglo-Indian is himself prevented from doing so, his wife and daughters might at any rate visit the Indian ladies. As to this, I dare to say that education and free intercourse with the world at large has rendered English ladies so immeasurably superior to those of India, that association of any kind except of a ceremonial nature is impracticable. It is not fair to ask, and but questionably prudent to encourage, a pure-minded and well brought up English girl to be on intimate terms with an average specimen of the zenana, until the latter is rendered more fitted for her society. The truth is that the want of companionship so observable between dark and fair in India is due, firstly, to Indian customs, and, secondly, to the low mental and moral condition of the well-born female population, and not, as is usually asserted, to British exclusiveness.

With reference to the rough sketch I have given you to-night of what I may term the normal state of things in India, I would again draw your attention to the fact that I am far from saying that such is the invariable rule, or from denying that there are whole castes whose women are not secluded, and that many are educated. I feel compelled to repeat that minute and endless variation is the chief characteristic of Indian society, in case it may still be thought that my analysis of a high caste Hindu woman's life is exactly applicable to that of every woman one meets in the roads and fields. The fact is there is no subject on which it is easier to speak to generalities from isolated facts, and it is so wide and complicated, that one can hardly make a broad assertion without with perfect truth being contradicted as to the specific custom at any given spot. I merely say that the above description is, as fairly as I can make it, applicable to the life actually led by millions of Indian women, and it is the style of life towards which nearly all of them unconsciously gravitate.

We naturally turn from the consideration of the life itself to that of the best method of changing or improving it. Many attempts are, of course, being made both by natives and Europeans to bring about a happier and more rational state of things. Among these may be reckoned the Zenana Mission, as to the good work of which many high hopes have been raised; but there would seem to be a fatal flaw in the theory on which the system is based. English ladies, often apparently completely ignorant of Indian ways, are sent out to mix as best they may with those of the Indian seraglios, in order to teach them the beauties of civilisation, and, I suppose, convert them to Christianity. Now, considering that the key to the seraglio is absolutely in the power of the owner thereof, it seems impossible to believe that he would admit outsiders within its walls if he thought that they would in any way be likely to influence the religion of his women. The heads of native families are far from being simple-minded, and most of them, if not bigots themselves, are sure to have bigoted wives; and since what access English ladies can have to the women generally rests entirely with these two authorities, I cannot quite understand how the members of the Zenana Mission differ in their action from those of any other missionary body. They may get into the houses of the native gentlemen who sympathise with the movement, but these must be the very few who have probably already themselves done much towards elevating the female members of their families; and how about the vast majority who have no desire for change? Either, it appears to me, the Zenana Mission ladies do not find their way inside their harems at all, or they do so purely as ordinary visitors. I would not, therefore, be inclined to place much faith in the efforts of these well-intentioned persons as likely to result in anything of practical value.

As regards the efforts of the natives themselves, there are societies started all over India, notably the orthodox Arya Samaj of the late Swami Dayananda Saraswati, which, though not nearly so "advanced" as the well-known Brahma Samaj of Keshab Chandar Sen, is doing much useful work in a quiet sober way towards the discontinuance of infant marriage, the promotion of the re-marriage of widows, and the advancement of female education. I need hardly remind my hearers that now-a-days neither infant marriage nor perpetual widowhood has the sanction of what the Hindus rather hazily regard as their Scriptures; a fact loudly proclaimed in Madras by Sir Madhava Rao, in Bombay by Mr. Malabari, in Northern India by Swami Dayananda, and in Bengal by the characteristically noisy Brahma Samaj. The effect of these societies is mainly visible on the surface in funny advertisements, in the style of the *Matrimonial News*, by young gentlemen willing to meet with widowed virgins possessed of certain qualifications. Ridiculous as their accounts of themselves are, and queer as appears to be their ideal of womanhood, the advertisers act in all earnestness, and their announcements are the outcome of an important social movement. Besides these, many cases have come under my personal notice of literate Hindus in all ranks of life, who—setting their faces against child marriage, often in the teeth of painful opposition, in a manner which does them all the more credit because they are in too humble a station to gain any notoriety thereby—are steadily educating their girls avowedly in the hope that those they hold dear may be saved from that life of empty superstition I have to-night endeavoured to bring before you. In education you will at once see lies the real remedy against nearly every evil to which Indian women at the present day are by custom liable. However, in considering the work of these reformers, we must not lose sight of those efforts, to which I alluded in the earlier part of my discourse, on the part of the low out-caste Hindus to be included within the pale of the orthodox by imitating their imperfections. Taken woman for woman, for the present at least, there is no doubt that there are far more women at the bottom of the tree who are being newly obliged to undergo seclusion and the miseries of Hindu widowhood, than there are at the top, whom growing enlightenment is releasing therefrom. Let us sincerely hope, nevertheless, that it is a race between the hare and the tortoise.

It is almost superfluous to add that, as one favourite panacea, our hot Indian reformers have urged repressive legislation, taking the abolition of *sati*, in 1829, as their example. It would be flogging a dead horse to argue now the uselessness of making laws about social customs; but a case has been lately before the Bombay Courts which seems to show that something can be done by legislation, or rather by the absence of laws, to help to cure the evil of infant marriage. The cause known as Rukmini Bái's case has so gone to the heart of the question as to have created a profound sensation in India, and simple though the issue is, it is likely to reach the Privy Council. From it, whatever be the final result, I suggest that we can learn a lesson. Briefly, the case is this:—Rukmini Bái, a Brahman lady, now of high education, was married as usual in her childhood to a boy of her own caste, who has turned out, in her opinion, to be an unfit companion for her, and she refuses to go to him; he accordingly sues for his conjugal rights. In pre-English days he would have had nothing but the force of custom and the right arms of his partisans to enable him to prosecute his claims, but under British rule the law steps in and enforces all contracts, and so far Rukmini Bái is likely to lose her cause. If, however, our laws were not to recognise betrothal, or marriage if you wish to call it so, as a contract legally entered into in their behalf by their lawful guardians, which infants were bound to fulfil on attaining puberty, a fatal blow would be struck at the custom. Parents and guardians would soon cease to enter into much expense over weddings, or to permit money to pass out of their hands over betrothals, which the infants would hereafter complete only to the extent their own inclinations or the persuasions of their friends might urge them.

Though we may not doubt that such endeavours as those just discussed to ameliorate the condition of the women will succeed in the end, we can hardly hope for much from them for a long while to come, and some of them may, after all, prove to be but a means towards the end; but there is one attempt, which is being made in the same direction, that is so practical and so certain to yield immediate good fruit, that I cannot better conclude my remarks this evening than by a reference to it—I mean the movement whose short title is Lady Dufferin's Fund. It will have been perceived that the essence of the life I have been to-night describing is confinement to the house—a life from which all healthy bodily exercise is under any circumstances absent. Now, this is bad enough in a palace, even where the palace consists of a collection of apartments inside a high-walled garden; but in India, as everywhere else, palaces are very few and far between, and space in towns is limited and valuable. There the common courtyard is contracted to a few feet square, forming a sort of well, round which the dwelling rooms run up several stories into the air, just as they do in London, and for the same reason. All native conservancy, too, regulates itself, except where the English interfere, and wherever their intervention is exercised native ingenuity is directed mainly towards the best means of thwarting their well-intentioned efforts. The true Indian has a deeply rooted conviction, born of Brahmanism, that water, as such, purifies all things, a theory that causes him immeasurable suffering in the present, and of which it is to be hoped for his own sake he will in the early future realise the terrible fallacy. If female life be necessarily unhealthy in the palaces, as undoubtedly it is, what must it be in the cramped imitations of the same to be counted by the thousand in the Indian townships? But these many-storied town dwellings are the mansions of the relatively rich, and are as very palaces in comparison with the much more numerous houses of the respectable possessors of small incomes. It has often been my duty, for various reasons, to inspect these humbler houses, and I will say that callous indeed must be the heart of him, that can mark the tumble-down mud hovels doing duty for the rooms, the sodden floor of the ten-foot square of bare earth that answers to the garden, the dingy, tattered rag that curtains off the zenana, the horrible half-hidden corner that is the family privy, and find no place for pity for those whom custom shuts up for life within the dilapidated mud walls that surround this apology for a home. High caste Hindus' houses are indeed often exquisitely clean, but many a Muhammadan dwelling I have entered is very much the reverse, and in either case the laws of sanitation are, to put it gently, not understood. Under such circumstances health is, as a matter of course, feeble, and disease of the respiratory and digestive organs rampant. Parturition, too, is, for reasons that will be readily understood, dangerous, and exceedingly painful. How important a point this last is may be explained by the fact that every woman, except the infant widow, is married, and that the most cherished desire of the sex is the bearing of a son. We are accustomed to be told that women have better chances of longevity than men; but look over the female death statistics in India, between the ages of 15 and 30, and you will find that circumstances can locally reverse a natural law. It was, then, with the object of preventing some at least of the unnecessary suffering caused by prejudice and custom—and, it must be added, by Indian midwifery—that the Countess of Dufferin took in hand her scheme of female medical aid for the women of India.

Lady Dufferin has herself, in the *Asiatic Quarterly Review*, so clearly and in so practical a manner described the origin, objects, and prospects of this beneficent movement, and the difficulties in the way of it, that it is needless for me to do more here than run over the heads of her statement, in order to show you what is being done. First comes medical tuition, next medical relief, and, lastly, the supply of trained female nurses and midwives. The immediate aims, you will perceive, are not very lofty, nor are they complicated; but in practice the idea underlying them goes to the root of the mischief it is sought to eradicate; for, where direct or implied missionary effort might for ever fail, attempts at the alleviation of purely physical suffering may well succeed; and it is a happy feature of the particular endeavours now being made that they must necessarily elevate the tone of the Indian female mind, because they include education of a right sort. When once they are entered upon, tact and a proper understanding of the questions involved will ensure ultimate success, and it is more than satisfactory to observe that both these qualifications are abundantly present in the authoress of this great movement. The careful readers of Lady Dufferin's modest article, written, by the way, I am told, against time during her late journey up the Irrawaddy, cannot fail to perceive that she is as practical as she is philanthropic, and that her scheme is born of no mere emotional haste to do good, but is the result of a calm survey of the end to be desired, a clear mind as to how it is to be attained, a full appreciation of the difficulties before her, and a firm determination to surmount them all. That all this augurs success it is needless to say, and if she succeeds—what a splendid achievement will be hers! In no part of the world is the saying that the history of the people is a thing apart from the record of politics so true as it is in India. There kings come and go, empires and systems, and faiths arise and disappear, but the development of the domestic economy proceeds along a path of its own; and it needs no great gift of prophecy to foresee that, if she succeeds in relieving the Indian women of all unavoidable suffering, and in giving a useful impetus to that right education on which their ultimate emancipation from unnecessary trammels depends, the name of Harriot Dufferin will stand in affectionate remembrance in many thousands of households as among the greatest benefactors that the land has ever seen—long after the current political storms have vanished into the regions of history; long after the highest of living reputations has died a natural death; and, it may be, longer after the British Empire in the East has become a thing of the past.

DISCUSSION.

Surgeon-Major PRINGLE said that having seen thirty years' service in India, the last twenty of which were spent in wandering from station to station in the sanitary department, he had probably seen as much of native life as most people. It was impossible to over-estimate the importance of this paper. The secret of the rise and progress of India lay in the family, and not in the school; and until this was realised, all their efforts would be like beginning a building at the top, there would be no solid foundation. In education, as regarded aptitude of hand or head, undoubtedly the native of India was capable of it to a very high degree. A nation which could calculate an eclipse long before England had the vestiges of civilisation, only required to have a fair chance to show that knowledge was still in the East. The real point to aim at, however, was the moral elevation of the people, and education alone could not do this.

They must go to the home, and begin with the mother. It was a terrible story they had heard; it might be a little strongly drawn, but perhaps the freedom and brightness of our own homes might make it appear darker in contrast. In any point of view it was a sad story, yet there might be in that home something which would send a boy out into the world with high moral principle to guide and direct him, but he feared it was but too rarely to be found. They were told education was to do it, but how was education to be got there. After many years' labour by the ladies who had worked in the Zenana Mission, it was now beginning to tell. He had no wish to detract in anyway from the scheme of Lady Dufferin; no one who had seen the misery he had witnessed, or who had examined the mortuary statistics as he had done, and had seen a birth and a death alongside of one another too often appearing down long columns of figures, would ever think of doing anything which could possibly throw any difficulties in the way of such a noble work, but it must be carried on in the only way in which such a work could be carried on, viz., in a spirit of self-devotion, even though the relief of human suffering was alone aimed at. Any one who had seen and known what a native house was, who had had to attend on native women, and seen their rooms and surroundings, would feel assured that nothing short of devotion to the work could carry a woman through it, and that devotion must arise from a higher principle than the hope of pecuniary reward. He knew the intention was to educate a certain class of women professionally, and send them out, but this was the outcome of work which had been going on for years, though perhaps it was not much known. There were many districts where ladies had visited the zenanas, and had taught the girls to read so that they could read to others, and though the beginnings were small, if the fruit were good, it would go on. What they had heard to-night, related to but, comparatively speaking, a small portion of the millons of females in India. There were a few people under these conditions, but there were millions who knew nothing of this seclusion, amongst whom often the mothers were little better than beasts of burden. Such was their lot in the hills. He had seen every class of women in India, from the leaf woman in Bengal, who wore nothing but leaves, up to the poor victim of polyandry in the North-West Provinces, and he knew what the misery of their lives was. They too often looked sickly and weak, and the reason was simply insufficient food; they only got the leavings, and not much of them. There was another thing which had not been touched upon. He had lived for years in a country where the awful practice of female infanticide had been carried on; but it had been prohibited, and the children were now, up to a certain age, carefully counted. When he first vaccinated in those countries, twenty-five years ago, the people brought out their girls in the hope that this would carry them off, but when it was found that the boys were carried off by small-pox and the girls lived, they changed their minds, and would not have the girls vaccinated. They felt it a hardship that they were forbidden to kill the female infants, for they said it was less of a pang to lose a child before they got to love it, than to have to part with it when a little older and had twined itself round their hearts; here, surely, is room for moral elevation. What was the origin of Suttee? It was simply a desire to suffer death by burning at once, to escape a worse fate for, it may be, years to come. He could endorse all that had been said, but it only related to a handful of the female population.

Mr. HYDE CLARKE said he should like to call Captain Temple's attention to one circumstance which might throw some light on the main part of the paper. He began by describing the Hindu woman's girlhood as a period of joy in many cases, but when it came to the period of womanhood or wifehood, that joy seemed to disappear altogether. But he thought that if the presence of the children in the household were borne in mind, that must be some alleviation of the dark picture which had been drawn. Probably Captain Temple's evidently accurate description required to be read through its text by the light of all that had been stated. A girl did not enter on life with such dismal hopes. She believed her apprenticeship was to lead to the splendid prize of female chief of the family. Our point of view of a wife was our own, it might be childless. Over the main part of the world, the mother and not the wife was the female centre. In those countries where, according to our notions, the women were enslaved—in China, India, and Turkey—there ruled that great female despot, the mother or mother-in-law. It must also be remembered that the condition he had described existed in other parts of the world, and human nature was, as he had said, much the same throughout. What he had said with regard to the time absorbed in religious ceremonies was a description of what would apply to the women of Southern Europe, particularly of Spain and Portugal, and, to a great extent, of Southern Italy. With regard to seclusion from general society, the same thing might be noticed amongst the Eastern Jews. The practice to which he had referred, of separate eating, was particularly kept up by many of the Jewish communities. He had had servants of his own eating food part of which he had eaten himself, but they had to go a certain distance—to the end of the compound—in order to be able to do so; they were not allowed to eat in strange society. He would rather dwell on the part of the paper in which it was said that this sad society was capable of improvement, than draw the conclusion that it necessarily meant that the life of the women in India was all sorrow. Captain Temple had warned them indeed that the circumstances of society varied in different classes and in different places. Dr. Pringle, who was a high authority, said they must not take too gloomy a view, and this was another reason why they might look with some hope on the efforts of Lady Dufferin. It would be totally impossible that she should accomplish in her time all that was required for the relief of the enormous population, but they might feel assured that what had been devised by her, following on the experience of men like Dr. Pringle himself, was calculated to achieve great practical good. He believed, too, from what he had seen in other places, that far more good would be done under Lady Dufferin's system than by the Zenana Mission. Captain Temple had very well described the difficulties of that system, which he had seen attempted to be introduced amongst Mussulman populations; it had never achieved much success, nor was it likely to do so. The women in any country in the world were those most attached to the religion of that country. The attempt, therefore, to introduce persons amongst them, under the idea of converting them, was unfortunately but too well calculated to prevent much good being achieved. Dr. Pringle had given evidence of the intelligence of the native population, but he did not understand him to claim that capacity for the boys alone. They might well believe that the girls were cleverer than the boys, for they were generally found so in most parts of the world, and it appeared there might be opportunities even in the life of a Hindu girl to obtain sufficient instruction to be able to read, so that she might be able to do as he said had already been done by some of the missionaries of the zenana—give a girl enough knowledge of reading to enable her to read not only to herself but to her companions. He had himself seen amongst Mussulman populations, where it was obligatory on the girls to go to school with the boys, that in a short time they had obtained a sufficient amount of instruction to enable them to read much that was useful to themselves and entertaining to their companions. He made these observations not by way of criticism, but rather in confirmation of what Captain Temple had said. It was very difficult to understand the real habits of the population, or the real condition of women in India or elsewhere, according to their own notions. It by no means followed because a woman carried heavy burdens that she was degraded to the position of a beast. That was a condition which was often undertaken voluntarily by the women themselves. A woman was proud that her husband should be thought a gentleman, and that he should walk about in all his finery, and she submitted to sacrifices in that way just as many a woman in this country submitted to the greatest sacrifices for the benefit of their families, if not of their husbands. He remembered on one occasion having a contract with some Turcomans, and when the troop came in the mules were all attended to and unloaded by women, while the men were decked out in all kinds of ornaments. The Europeans about him said, "You see how the women are treated," thinking no doubt it was very barbarous; but when he had paid the chiefs, he caused a question to be put to them, whether they or their wives would keep the money. Of course, if he had asked them himself, the answer would have been, as in India, whichever they thought would please him best; and as it was, the first reply was—"What answer do you want?" On being informed that he simply wanted to know what was the real fact, the answer was, "The money will go to our wives; we shall merely have a small sum out of it for tobacco." He was not surprised, because on holidays he had seen these ladies covered with gold ornaments, and in rich dresses. It was evident that they considered it a matter of dignity that their husbands should appear in this way, as his equals, although at the expense of some trouble to the women, which after all was perhaps more of a pleasure than a trouble. Many ladies in England would understand this, for although they were not in the habit of loading or unloading mules, or physically carrying burdens for their husbands, they often knew what it was morally to bear a burden for the sake of their husbands and families.

Captain TEMPLE, in reply, said Dr. Pringle thought his picture was somewhat gloomily drawn, but his impression was that he had drawn it as brightly as possible. Nothing but a gloomy picture could be drawn of Indian life of the sort he had been describing. If he had read extracts from the books he had named as being worth study, it would have been found that things written by the natives about themselves were infinitely more gloomy than anything he had said; and, in fact, he thought Dr. Pringle's own picture was much more so. He said the life he had described applied fully to only a very few, but he had twice repeated in the paper that it was impossible in so large and heterogeneous a country to describe the life of any class which would not be found to clash with that of some other class in some part of India, but was the model upon which Indian female life generally was conducted. He fully endorsed Mr. Hyde Clarke's statement that the kind of life he had been describing was capable of explanation by the study of anthropology, and no doubt if the subject were studied by the aid of parallel customs in other parts of the world, it would be found that there was a reason for the way in which Indian female life had been developed. He did not think Lady Dufferin had ever pretended to be the originator of the system of medical aid for women; her merit was in having given such an impetus to the movement as was likely to make it a success. As to the Zenana Mission he did not mean to say it had done no good, but there was a flaw in the system upon which it was conducted. It was impossible for an English lady, or any English person at all, to get inside a Muhammadan or any other house where there was a zenana, unless the owner of the house gave his consent, and that made him think that the Zenana Mission could not differ much from any other mission, except in name.

The CHAIRMAN said he had been called upon rather suddenly to occupy that position in the place of Mr. Gibbs, and he was not prepared to say much upon this very important and interesting paper. To those who knew what Captain Temple's work had been, there could be no doubt that he would not come forward without a great deal of well sifted matter; for he (the Chairman) knew no man in the Indian service who had so large a variety of knowledge of Indian life, and customs, and languages, as was shown in the many publications which he directed. This was not merely a paper produced by a clever man who could turn on a stream of talk on any given subject; it was a careful and diligently compiled statement, arrived at with great labour after long study. The end to which it was directed was, he should gather, to stimulate interest in Lady Dufferin's scheme, and this was a most desirable object. It was not merely to give curious details upon the life of the zenana women in India, but it had a practical bearing. He must say, however, that in one point which had been already glanced at by Dr. Pringle, Captain Temple had not spoken with that accurate knowledge which he had shown in the remainder of his paper. He seemed to speak of the Zenana Missions merely out of his inner consciousness, and of what he thought *a priori* would be the result of them, but here he thought his inner consciousness had led him astray. The results of the operations of the Zenana Missions were exceedingly remarkable. Captain Temple had spoken of the rarity and difficulty with which English ladies entered the zenanas and formed any acquaintance with the inmates. It was exceedingly difficult and exceedingly rare, and in his own small experience in former days he had hardly even known an instance of it; but since the establishment of these societies, of which there were at least two great societies and some minor ones, there were scores of intelligent and devoted English ladies—probably not less than two hundred—engaged in making intimate acquaintance with the ladies of zenanas to which they had admission; and admission to those zenanas was not regulated by that *a priori* judgment which Captain Temple had formed. He could not account for the motives of men, nor could he regulate them by *a priori* considerations, but it was a fact that a great many Hindus especially, but also some Mohammedans, did give free access to these ladies to the interior of their homes, and that access was never sought without the distinct intimation that the Scriptures should be read, and Christian teaching given. From time to time, doubtless, doors were closed against these ladies, but others were opened. And the result was that they were doing a great work in mitigating the unhappy condition which had been so graphically pictured. Lady Dufferin's scheme was a great one, and the eloquent conclusion of the paper only did justice to what she was endeavouring to do so energetically. But what was the origin of it? He would not say the work would not have come about in other ways, any more than one could say that if Columbus had never lived America would not have been discovered, or that without Guttenberg printing would not have been invented, or that the steam-engine could never have been perfected but for James Watt; but, as a matter of fact, the origination of this medical care of the women of India lay directly with the Zenana Missions. It was owing to a medical lady of one of those missions having had a message to Her Majesty the Queen from a certain Maharani in Bundelkund, whom the lady had attended in illness, that the first discussion in the Press on this subject of female attendance on women originated, and that discussion distinctly gave rise to Lady Dufferin's project for the large extension of the system apart from religious teaching. Captain Temple had spoken correctly of the gloomy character of Indian life, especially on the Bengal side of India (for he believed that in the west things were somewhat different); and no one could look back to a long residence in the valley of the Ganges without reflecting on the extremely uncheerful character of the people. It had been his fortune to visit Burmah and Java, and also to live amongst the hill people on the eastern frontier of Bengal, and the contrast in this respect was certainly wonderful. There was an habitual cheerfulness amongst those eastern populations which one missed entirely in Gangetic India. Some of the agitators who were so busy nowadays in the disparagement of the British government of India would say that was the cause of it, but he was certain this would be an entire mistake. No such consequences were found in Burmah, part of which had been fifty years under British rule; nor in Java, which had been nearly three centuries under the government of another European nation, whose rule was certainly, to say the least, not more considerate towards their subjects than that of the English. He believed that, in fact, the domestic system which had been described, and which was in entire contrast to the manners of those people further east, had a good deal to do with the exceedingly uncheerful character of the people. He concluded by proposing a hearty vote of thanks to Captain Temple, which was carried unanimously.

According to the statistics recently published by the Minister of Agriculture and Commerce, it appears that the quantity of olive oil produced last year, in the various provinces throughout Italy, was 52·34 per cent. below the average annual yield, which is calculated at 3,405,500 hectolitres (74,921,000 gals.), it being only 1,782,400 hectolitres (39,212,800 gals.); 11 per cent. of this total amount was of superior quality, 73 good, and 16 per cent. mediocre.

Miscellaneous.

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COLONIAL AND INDIAN EXHIBITION.

CONFERENCES.

The following are the arrangements for meetings previous to Whitsuntide. The days given below are subject to revision. The meetings are open to all visitors to the Exhibition:—

Friday, May 28.—Conference of the Royal Colonial Institute. Paper by F. B. Labilliere, "Imperial Federation." 3.0 p.m.

Monday, May 31.—P. L. Simmonds. Paper, "Our Colonial Wool Supplies." 4.0 p.m.

Tuesday, June 1.—Conference of the Anthropological Institute. 4.0 p.m. "Native Races in British Possessions in Africa."

F. W. Pennefather, Lecture, "A Tour through New Zealand" (with limelight illustrations). 8.30 p.m.

Wednesday, June 2.—S. B. L. Druce. Paper, "Importation of Grain and Bread-Stuffs from the Colonies and India." 4.0 p.m.

Thursday, June 3.—Arnold White. Paper, "South Africa as a Field for the Emigration of the Industrial Classes." 4.0 p.m.

Friday, June 4.—Conference of the Royal Colonial Institute. Paper by J. D. Wood, "The System of Land Transfer adopted by the Colonies." 3.0 p.m.

Saturday, June 5.—Conference of the Geologists' Association. Paper, Prof. Valentine Ball, F.R.S. "The Mineral Resources of India." 3.0 p.m.

Monday, June 7.—Conference of the Anthropological Institute. "Native Races in British Possessions in America and the West Indies." 4.0 p.m.

Tuesday, June 8.—Conference of the National Association for Promoting State-directed Colonisation. 2.0 p.m.

Alexander Begg, Lecture, "The Canadian North-West." 8.30 p.m.

Wednesday, June 9.—L. J. Shand. Paper, "British-Grown Teas." 4.0 p.m.

Thursday, June 10.—F. W. Pennefather, Lecture, "The Industries of New Zealand." 8.30 p.m.

Friday, June 11.—Conference of the Royal Colonial Institute. Paper by F. Young, "Emigration to the Colonies." 3.0 p.m.

The Papers will be followed by discussion. There will be no discussion after the Lectures.

ROYAL VISIT.

On Friday morning (May 21st) her Majesty the Queen visited the Exhibition. Her Majesty—accompanied by H.R.H. Princess Beatrice, and attended by Lady Southampton, General Lynedoch Gardiner, and Sir Henry Ponsonby—arrived at the India Museum entrance of the Exhibition at a quarter to eleven o'clock, where she was received by H.R.H. the Prince of Wales, K.G., the Executive President of the Royal Commission, and by Sir Philip Cunliffe-Owen, K.C.M.G., C.B., C.I.E., Secretary to the Royal Commission. Colonel Teesdale, V.C., C.B., was in attendance on H.R.H. the Prince of Wales. Her Majesty was joined at the entrance by H.R.H. the Duchess of Albany, attended by Miss Collins. In the West Indian Court the band of the 1st West Indian Regiment was drawn up and played a selection of music. Lieutenant Norris, who is in charge of the band, had the honour of being presented to her Majesty. The Queen proceeded through the West Indian Court, where she was received by the Executive Commissioner, Mr. A. J. Adderley, C.M.G., to the British Guiana Section, where she was received by Mr. Hawtayne, the Executive Commissioner; and to the Hong Kong Section, where she was received by Mr. Wodehouse, the Special Commissioner from Hong Kong. Her Majesty next visited the Straits Settlements Section, where she was received by Mr. Swettenham, the Executive Commissioner; and then proceeded to inspect the agricultural trophy in the Canadian Section, where she was received by Sir Charles Tupper, G.C.M.G., and Lady Tupper, who had the honour of presenting to her Majesty a bouquet. The Queen proceeded through the Queensland Court, where she was received by Mr. Garrick, C.M.G., the Executive Commissioner, and through the Western Australian Court, where she was received by Mr. Malcolm Fraser, C.M.G., the Executive Commissioner, and Mr. Alpin Thomson, the Assistant Commissioner. In the New South Wales Court her Majesty was received by Sir Alexander Stuart, K.C.M.G., the Executive Commissioner, and by Captain Loftus, the Secretary to the Commission. On entering the Victorian Section, her Majesty was received by Mr. Graham Berry, Executive Commissioner, Mr. Bosisto, President of the Commission, and by Mr. James Thomson, Secretary to the Commission. The Queen then entered the "Old London Street," and proceeded thence to the Indian Palace, and inspected the natives at their work. Dr. Tyler, who is in charge of the natives, was in attendance, and explained the various manufactures. Returning through the "Old London Street," the Queen passed through another section of the Victorian Court, into the Fiji Section, where she was received by Mr. James Mason, the Executive Commissioner; and then entered the South Australian Section, where she was received by Sir Arthur Blyth, K.C.M.G., the Executive Commissioner. and Sir Samuel Davenport, the Commissioner in charge of exhibits. Her Majesty then re-entered Canada, and inspected the furs and the hunting trophy, and made a few purchases of furs. The Queen inspected the geological collection of the Canadian Section; the various specimens were explained to her by Dr. Selwyn, who is in charge of this department. After leaving Canada, her Majesty entered the New Zealand Court, where she was received by Sir Francis Dillon Bell, K.C.M.G., the Executive Commissioner, and by Dr. Von Haast, C.M.G., the Commissioner in charge of exhibits. In the Cape of Good Hope Court, her Majesty was received by Sir Charles Mills, K.C.M.G., the acting Executive Commissioner, and by Mr. Sydney Cowper, the Secretary to the Commission. Her Majesty inspected the diamond washing and cutting machinery, as well as the Cafirs, Bushmen, and Malays. Her Majesty then visited the Natal Section, where she was received by Sir William Charles Sargeaunt, K.C.M.G., the Executive Commissioner; and from there proceeded to the West African Court, where she was received by Sir James Marshall, the Executive Commissioner. Her Majesty left the Exhibition by the Queen's-gate entrance, at a quarter-past twelve o'clock.

The number of visitors to the Exhibition for the week ending May 22nd, was 140,533; making a total since the opening of 386,111.

Obituary.

Mr. J. T. Stanesby.—John Tatam Stanesby, a member of the Society of Arts since 1870, died on March 10th. Mr. Stanesby was born in London on January 7th, 1819, and at an early age received medals from the Society for his engravings. In 1835, he obtained the silver Isis medal "for a wood engraving copied from a print," and in the following year a large silver medal "for a wood engraving of figures." He wrote several articles for the "Penny Cyclopædia," and for other publications of the late Mr. Charles Knight.

MEETINGS OF THE SOCIETY.

Cantor Lectures.

The Sixth Course will be on "Animal Mechanics." By B. W. Richardson, M.A., M.D., F.R.S.

Lecture V.—May 31.—Mechanisms continued; and Review in regard to practical applications.

MEETINGS FOR THE ENSUING WEEK.

Monday, May 31...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. (Cantor Lectures.) Dr. Richardson, "Animal Mechanics." (Lecture V.)

Colonial and Indian Exhibition, South Kensington, S.W., 4 p.m. Mr. P. L. Simmonds, "Our Colonial Wool Supplies."

British Architects, 9, Conduit-street, W., 8 p.m.

Tuesday, June 1...Colonial and Indian Exhibition, South Kensington, S.W., 4 p.m. Conference of the Anthropological Institute. "Native Races in British Possessions in Africa." 8½ p.m. Mr. E. W. Pennefather, "A Tour through New Zealand" (with Lime-light Illustrations).

Royal Institution, Albemarle-street, W., 3 p.m. Prof. A. Gamgee, "The Function of Circulation."

Central Chamber of Agriculture (at the House of the Society of Arts), 11 a.m. Special General Meeting.

Zoological, 11, Hanover-square, W., 8½ p m. 1. Dr. Günther, "Exhibition of a Specimen of a Fish Embedded in a Pearl Oyster." 2. Mr. F. E. Beddard, "Note on the Trachea of a Curassow" *(Nothocrax urumutum)*. 3. Mr. W. F. Kirby, "A Collection of Dragonflies from Murree and Campbellpore (N.W. India) received from Major J. W. Yerbury."

Wednesday, June 2...Colonial and Indian Exhibition, South Kensington, S.W, 4 p.m. Mr. S. B. L. Druce, "Importation of Grain and Bread-Stuffs from the Colonies and India."

Entomological, 11, Chandos-street, W., 7 p.m. 1. Dr. J. S. Baly, "Descriptions of uncharacterised species of *Diabrotica*." 2. Mr. Arthur G. Butler, "Descriptions of new genera and species of *Lepidoptera - Heterocera*, from the Australian Region."

Archæological Association, 32, Sackville-street, W., 8 p.m. 1. Mr. A. Brent, "Notes on Ancient Seals." 2. Mr. Geo. R. Wright, "Recent Discovery of a Roman Villa at Reims." 3. Mr. E. Walford, "Painted Glass at Oriel College, Oxford."

Obstetrical, 53, Berners-street, 8 p.m.

United Service Institute, Whitehall-yard, S.W., 3 p.m. Major E. T. H. Hutton, "Mounted Infantry:—(1.) An Adjunct. (2.) An Auxiliary to Cavalry. (3.) The Volunteer Force in its relation to Mounted Infantry. (4.) Remounts for an Improvised Mounted Force."

Thursday, June 3...Colonial and Indian Exhibition, South Kensington, S.W., 4 p.m. Mr. Arnold White, "South Africa as a Field for the Emigration of the Industrial Classes."

Linnean, Burlington-house, W., 8 p.m.

Chemical, Burlington-house, W., 8 p.m.

Society for the Encouragement of Fine Arts, 9, Conduit-street, W., 8 p m. Mr. Brodie Innes, "The Origin and Development of the English School of Poetry."

South London Photographic, (at the House of the Society of Arts), 8 p.m.

Royal Institution, Albemarle-street, W., 3 p.m. Prof. A. Macalister, "Habit as a Factor in Human Morphology."

Archæological Institution, 16, New Burlington-street, W., 4 p.m.

Friday, June 4...Royal Institution, Albemarle-street, W., 8 p.m. Weekly Meeting, 9 p.m. Dr. W. H. Gaskell, "The Sympathetic Nervous System."

Geologists' Association, University College, W.C., 8 p.m.

Colonial and Indian Exhibition, South Kensington, S.W., 3 p m. Conference of the Royal Colonial Institute. Mr. J. D. Wood, "The System of Land Transfer adopted by the Colonies."

Philological, University College, W.C., 8 p.m. Dr. W. Stokes, "The Independent and Dependent Forms of the Old Irish Verb."

Saturday, June 5...Royal Institution, Albemarle-street W., 3 p.m. Prof. G. G. Stokes, "Light, with special reference to Effects resulting from its Action on various Substances."

Colonial and Indian Exhibition, South Kensington, S.W., 3 p.m. Conference of the Geologists' Association. Professor Valentine Ball, "The Mineral Resources of India."

Actuaries, The Quadrangle, King's College, W.C., 3 p.m. Annual Meeting.

Correction.—Page 724, col. 1, lines 26 and 31, *for* 1,200,000,000,000 *read* 1,200,000,000,000,000.

Journal of the Society of Arts.

No. 1,750. Vol. XXXIV.

FRIDAY, JUNE 4, 1886.

All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

NOTICES.

ALBERT MEDAL.

The Council of the Society of Arts have (with the approval of the President, H.R.H. the Prince of Wales) awarded the Albert medal to Mr. Samuel Cunliffe Lister, "for the services he has rendered to the textile industries, especially by the substitution of mechanical wool-combing for hand-combing, and by the introduction and development of a new industry—the utilisation of waste silk."

MEDALS.

The Council have awarded the Society's Silver Medals to the following readers of papers during the Session, 1885-6:—

To Prof. Francis Elgar, LL.D., for his paper on "The Loadlines of Ships."

To Henry Davey, for his paper on "Machinery in Mines."

To Prof. W. C. Unwin, for his paper on "The Employment of Autographic Records in Testing Materials."

To C. V. Boys, for his paper on "Calculating Machines."

To Prof. Leonard Waldo, D.Sc., for his paper on "Watch-making by Machinery."

To John Mackenzie, for his paper on "Bechuanaland and Austral Africa."

To Edward Combes, C.M.G., for his paper on "The Industries and Commerce of New South Wales."

To G. Gordon Hake, for his paper on "Cyprus since the British Occupation."

To Prof. W. N. Hartley, F.R.S., for his paper on "Photography and the Spectroscope in their Application to Chemical Analysis."

To Prof. R. Meldola, for his paper on "The Scientific Development of the Coal Tar Colour Industry."

To B. H. Baden Powell, C.I.E., for his paper on "Indian Manufactures from a Practical Point cf View."

To Capt. Richard Carnac Temple, for his paper on "Everyday Life of Indian Women."

Thanks were voted to the following members of the Council for the papers read by them:—

To Capt. Douglas Galton, D.C.L., C.B., F.R.S., for his paper on "Results of Experiments on Mechanical Motors for Tramways made by the Commission at the Antwerp Exhibition."

To W. H. Preece, F.R.S., for his paper on "Domestic Electric Lighting."

CONVERSAZIONE.

The Society of Arts Conversazione will be held, by permission of the Royal Commission, at the Colonial and Indian Exhibition, South Kensington, on Friday, the 16th of July next.

Each member will receive a card for himself, which will not be transferable, and a card for a lady. In addition to this, cards will be sold to members of the Society, or to persons introduced by a member, at the following prices:—Until the 3rd of July, 7s. each; after that date 10s. each, except on the 16th July, when the price will be 15s.

The Council, however, reserve the right of stopping the sale of tickets or of raising the price, if it is found necessary, in order to restrict the number of visitors within reasonable limits.

Tickets will only be supplied to persons presenting members' vouchers (forms of which can be obtained from the Secretary), or a letter of introduction from a member.

Members can purchase these additional tickets by personal application, or by letter addressed to the Secretary. In all cases of application by letter, a remittance must be enclosed. Each ticket will admit one person, either lady or gentleman.

Light refreshments (tea, coffee, ices, &c.) will be supplied at the usual buffets. No refreshments can be obtained by purchase. It will greatly facilitate the arrangements if members requiring additional tickets will apply for them at as early a date as convenient. The members' invitations will be issued early in June. Visitors' tickets can be purchased from the present date.

There will be no admission to the Exhibition on this evening except by special ticket, and no tickets can be purchased at the Exhibition.

Further particulars as to the arrangements will be announced in future numbers of the *Journal*.

CANTOR LECTURES.

Dr. B. W. Richardson, F.R.S., delivered the fifth and last lecture of his course on

"Animal Mechanics" on Monday evening, May 31st. A vote of thanks was passed to the lecturer on the motion of the Chairman (Mr. B. F. Cobb).

The lectures will be printed in the *Journal* during the summer recess.

Proceedings of the Society.

FOREIGN & COLONIAL SECTION.

Tuesday, May 25, 1886; Major-General Sir Robert Biddulph, K.C.M.G., C.B., in the chair.

The paper read was—

CYPRUS SINCE THE BRITISH OCCUPATION.

By G. Gordon Hake.

Introduction.

The title of this paper indicates the object I have had in view in preparing it, viz., to briefly recapitulate the improvements in the commerce of the island, and the condition of the people since they have been under English administration; and in order to do this it will be necessary to pass in review their social condition, laws, and government previous to our occupation. Having done this, I propose to offer some suggestions as to what still remains to be accomplished in order to develop fully the great resources of the island.

I trust that I shall not be considered wanting either in courtesy to my audience or respect for my subject because I have only brought a few maps and statistical diagrams with me; but as you all know, Cyprus, though not exactly a colony, has been allotted a court in the Colonial and Indian Exhibition at South Kensington—and I would ask you to supplement this paper by a visit—where a very fair sample of the industries and products of the island can be seen; and for detailed information about the island generally, no better reference can be made than to the list of Blue-books which I have appended to this paper.

Geography.

It may, however, be as well at the outset to give a few particulars of the geography of the island, as this will assist to a better understanding of the various questions touched upon. The island of Cyprus is situated in the easternmost basin of the Mediterranean Sea, with Asia Minor to the north of it and Syria to the east, at distances of 60 and 41 miles respectively. The port of Larnaca, on the southern coast, is 258 miles from Port Said, and 1,117 miles from the harbour of Valletta, in Malta. Cyprus is the third largest island in the Mediterranean, and its area is 3,584 square miles. Its greatest length is about 140 miles, and its breadth 60. In shape the ancients compared it to the outspread skin of a deer. Its main topographical features are the northern and southern mountain chains, and the great plain of the Mesaoria extending from the Bay of Morphou to Famagusta. The rivers are nearly all mountain torrents, dry in summer.

Population.

The population is 186,173, of whom the Moslems form about one-fourth, the rest being nearly all Christians of the orthodox Greek Church. Their natural disposition is loyal and orderly, and they evince satisfaction and contentment with their lot.

History.

Few countries possess a more singular and romantic history than the island of Cyprus. Its original discovery is merged in the gloom of the heroic ages, but it was probably peopled from Lycia, although the Phœnicians were the first colonists of whom we have authentic records. It belonged at different periods to the Egyptians, Assyrians, Persians, and Romans, besides being independent at various periods of its history. On the breaking up of the Roman Empire it fell into the hands of the Byzantine Emperors, who retained it till the 12th century. In the year 1184, an independent sovereignty was established, which, however, only lasted till 1195, when Richard I. of England conquered the island, and soon after bestowed it on Guy de Lusignan, King of Jerusalem, whose dynasty continued in power for over three centuries. The Genoese and the Venetians succeeded the Lusignan monarchs, and they in turn succumbed to the Turks, who, after experiencing a protracted and sanguinary resistance, became masters of Cyprus in 1571. Rather more than 300 years of Turkish rule followed, the next change being effected by the Anglo-Turkish Convention of 1878, by which the island was practically ceded to Britain, the terms of Convention being that England engaged to join the Sultan in defending his Asiatic possessions against Russia in certain contingencies, and the Sultan, in order to enable England to make necessary provision for fulfilling her engagements, consented to assign the island of Cyprus to be occupied and administered by England. The British Government, on their part, agreed to pay the excess of revenue over expenditure in the island, to be calculated upon and determined by the average of the five years preceding the date of the Convention, to be verified hereafter. I shall refer to this subject later on, but may here state that this payment amounts to £92,800 yearly.

Throughout the whole period of its history previous to the conquest by the Turks—a period embracing more than 2,000 years—the island was a place of great importance, and flourished to an extent almost incredible, when viewed in the light of its present condition. The greatest warriors fought for its possession, to which they attached an exceptional value, as being the key to the East, its proximity to Egypt, Greece, and Asia Minor rendering it of the utmost consequence in determining the balance of power in the wars that were so frequently waged between the various dynasties of the East. Nor was its situation in the Mediterranean the only reason for the jealous eye so frequently cast upon it. Anciently covered with the most valuable timber, and endowed with a soil rich in mineral wealth, as in native fertility, it furnished vast numbers of ships for the fleets of its rulers, as well as metal for the manufacture of swords, armour, and other articles in bronze, which formed the staple trade of Cyprus from the earliest times. The mineral for which it was especially famous was copper, the name of which, indeed, is traced to the island from its Latin designation—*æs cyprium*, or *cuprium*. Although much of the timber must have been used in early times for the construction of ships, and in connection with the smelting of ores, without serious detriment to the forests, it is held that the great and indiscriminate demand for material for shipbuilding, &c., made during the earlier centuries of the Lusignan dynasty, was the first step towards their impoverishment. Three centuries of utter neglect and wasteful felling, and to this must be added the ravages due to uncontrolled pasturage of goats during the Turkish administration, completed the ruinous state in which we found the forests on our occupation in 1878.

Mussulman dominion has seldom proved advantageous to the conquered race, and there are several reasons why Cyprus formed no exception to this rule. The stubborn resistance offered to the invader, who only achieved victory after a year of hard fighting, with the loss of thousands upon thousands of troops, and by the exercise of perfidy towards a courageous foe, engendered a spirit of revenge which the Turk was not slow to act upon. Then, again, for a time, Cyprus was an appanage of the Grand Vizier, who obliged the governor, by measures the most oppressive, to remit an annual revenue much exceeding the resources of the inhabitants. Annual emigration of large numbers was the natural consequence, while of the remaining population, Dr. Sibthorp, the naturalist, who visited the island about the end of last century, remarks that, "induced at first, perhaps from necessity, to practise some low tricks of lying and knavery, these may at length from frequent repetition have become habitual among many of them." The same authority describes Famagusta, at the time of his visit, as a "melancholy picture of Turkish desolation," and as "almost depopulated, although, in the time of the Venetians, the finest city in the island, and renowned for its brave defence against the infidels." He adds, "the desolation we observed at Famagusta extended itself along the country. We passed by the ruins of several Greek villages." Another traveller, Dr. Clarke, also gives a sad account of Cyprus at a rather later date. "The island," he says, "was formerly one of the richest and most fertile in the world. It is much exposed to the ravages of locusts. On their approach, every kind of verdure disappears, and they even gnaw the very bark off the trees. The Turks will not permit their destruction, because they consider them as sent by the Almighty."

OTTOMAN SYSTEM OF ADMINISTRATION.

The vast deterioration of the physical resources of the island while in Turkish hands may be traced primarily to the neglect of the forests, and the wholesale destruction of timber. That again reflects back upon the people, whose condition, however, was very much due to the system of Government under which they lived. Yet in theory, the system of administration followed by the Ottoman authorities in Cyprus was one of extreme symmetry. The island formed a *sandjak*, or *arrondissement*, in the vilayet or province of the isles of the White Sea; and was itself divided into six *cazas*, or districts, which were again subdivided into sixteen *nahiehs*, or sub-districts. Each *caza* was administered by an officer called a *kaimakan*. Beneath the *kaimakan* and in charge of each *nahieh*, was a *mudir*, while every village had a *mukhtar*, or headman. This *mukhtar* was the local collector of taxes, and it was his business to carry his collections direct to the *caza* treasury, the *kaimakan* periodically remitting the proceeds obtained from his entire district to the headquarters at Nicosia. The revenue was derived from the following classes of imposts :—

(1.) *Verghi*, which may be roughly stated as a property and income tax.

(2.) Military exemption tax.

(3.) Sheep tax.

(4.) Customs and Excise, the former being, broadly, 8 per cent. on all imports, and 1 per cent. on all exports, while the latter included, besides licenses on the sale of wine and tobacco, a duty of 10 per cent. on the value of all wine manufactured in the country.

(5.) Salt, which was a strict monopoly of the Turkish Government, yielding about £17,000 per annum.

(6.) There were also a variety of minor taxes. The bulk of the revenue, however, was obtained from the

(7.) Tithes or Government share of the produce of land, and to the maladministration of this branch of revenue collection was due, in large part, the steady decline in the prosperity of the people.

TITHE FARMING.

It was the custom of the Turkish Government to farm the tithes to merchants and speculators in the spring of each year, when the ripening crops enabled all concerned to estimate the extent and quality of the year's produce; the sales of tithes commencing in March and ending in June. When these sales were effected, the tithe farmer was required to sign a bond for the amount, payable in six monthly instalments, beginning on 1st August. After conclusion of the agreement, the tithe farmer proceeded at once to watch the fields in which he was interested, and to estimate the yield. He saw the grain cut, threshed, and heaped, and insisted on its remaining on the floor until his claim was satisfied—the claim always exceeding the stipulated tenth. For wheat, barley, and other grain, arrangements had to be made by the cultivators for transit to the nearest port of embarkation, on terms more or less unfavourable to themselves. Their cattle were taken away for transport when most required in their own fields; and they had to bear all the expenses of transit except the expense of the first mile, which was paid by the tithe farmer. For fruit, vegetable, and other perishable articles, the tithe was commuted for a money payment, respecting which there were usually disputes, determinable by the *kaimakan*, who decided, as a rule, in favour of the tithe farmer, the latter being usually a member of the administrative council and a person of some influence. Later in the year—about the middle of August—the vineyards were similarly visited by the tithe farmer or his representative, and estimates of the produce made by them and by the cultivators. These estimates always differed, and were the subject of constant disputes, which were again referred to the *kaimakan*, whose award was, of course, in favour of the tithe farmer. As the grapes could not be removed until the claim was settled, the cultivator would submit to the exactions of the tithe farmer rather than risk the deterioration or loss of his stock, being thus practically mulcted in proportions far exceeding a tenth of the entire produce.

But, though keen in their dealings with the peasantry, the tithe farmers were slow enough in their own payments to the Government. These were often delayed on various pretexts, and remissions frequently obtained through collusion with the local *kaimakans*. Thus, while recovering far more than the actual tithe directly the crops were gathered, the tithe farmer often indefinitely postponed, and sometimes evaded altogether, his obligation to the State treasury.

This extraordinary system had its natural results in a loss of revenue to the State, and the impoverishment of the cultivator, whom it involved in the toils of the money lender, as well as the tithe farmer, and thus checked the productiveness of the island to an enormous extent. The land, falling out of cultivation, became the breeding ground of locusts. The cultivators of the soil in many cases gave up their calling in despair, and obtained a living by cutting down and selling trees, and the collection of resin. The wholesale destruction of trees reacted on the climate, and restricted the rainfall; so that between locusts, tithe farmers, and neglect of the forests, the island at the time of the occupation was rapidly becoming more like a barren rocky desert than a fertile and naturally favoured country.

These, then, were the chief evils to be remedied by the English on their arrival in Cyprus.

CURRENCY.

One of the first questions, however, that was forced on the consideration of Lord

Wolseley was that of the currency. The currency generally in circulation was caïmé, in which 250 piastres went to the Turkish pound; copper requiring 160 piastres, and metalliques 120 piastres, to make up the same amount. The great fluctuations to which Turkish currency is liable made it evident that the continued use of these media of exchange would end in the utmost confusion, and possibly in financial disaster; and there was substituted without delay, though by no means too soon, as the event proved, an English copper piastre, with shillings and pounds sterling, nine piastres going to the shilling and 180 to the pound. This established on a firm basis the currency of the island, and fixed the way for the other improvements necessary.

TITHE REFORM.

While many of the taxes I have mentioned were subjected to alteration so as to fall less heavily upon the people, the more drastic remedy was in the tithe portion of the revenue. It was at once made plainly known that no farming of tithes would be allowed under British rule; and it was decided to adopt the following course in regard to the same. The Turkish plan of assessment was to be followed, but, instead of collecting the tithes in kind, they were to be valued, and, leaving the peasant free to deal with his crop as he pleased, the money value was to be collected as an ordinary tax later in the year. The sole exceptions to this were the tithes on silk and carobs. The greater portion of these two products being exported from the island, it was arranged to collect the tithe on export, and so save the cost of assessment; and the result, besides being successful from the imperial point of view, has given great satisfaction to the agriculturists.

LOCUSTS.

Two crying evils, those of currency and tithe farming, were thus remedied; but the locust and timber questions remained to be dealt with. The Cyprus locust is indigenous to the island, and its presence is, without doubt, largely due to past mismanagement and neglect of the soil, inasmuch as it is only on rocky waste ground that the female insect will lay her eggs. The locust plague is therefore the result of inadequate cultivation of the soil, consequent upon a deficiency of population, coupled with an insufficiency of trees, though their increase may be largely attributed to the Mussulman theory of resignation, which would not, in former times, permit their destruction on account of the belief that they were sent by the Almighty. For some years prior to 1862, the destruction of crops from this cause was very large, and the plan of egg collection was then tried, without success, by the Turkish Government. This led Mr. Richard Mattei, a landowner of Cyprus, to commence a series of experiments, which resulted in the invention of his system of traps and screens. Mr. Mattei had the good fortune to secure the assistance of the Turkish governor, Said Pasha, a man of exceptional intelligence and energy, and in 1870, after long effort, the locusts were by this means almost exterminated. Not wholly, however, for in 1875 they reappeared, and, another governor being in power, they were allowed to increase until the time of the British occupation. Early in 1879, measures were adopted by the English Government, both by the employment of Mr. Mattei's trap and screen system, and by encouraging the collection of locust eggs, for which they offered a considerable price. These measures resulted in the collection of 37½ tons of eggs, but next year showed greater numbers to combat with. Again the traps were resorted to, and there was likewise temporarily enforced a Turkish law rendering every male liable to contribute a certain quantity of locust eggs. The ensuing destruction of eggs amounted to 236 tons, but still the following spring revealed no diminution but rather an increase in the number of insects. The succeeding autumn and winter witnessed the collection of 1,330 tons of eggs, and in the spring of 1882 over 6,000 screens were employed for the destruction of the locust swarms. This was the turning point of the battle, 195,000,000,000 of insects being estimated as destroyed. Precautions, however, were not relaxed. During the next two years immense numbers of locusts were destroyed, and the system of trapping, together with the organisation of the necessary labour, brought to a state of perfection by Mr. Samuel Brown, the Government engineer. There are now available for use over 11,000 screens and 13,000 traps, the former representing an aggregate length of about 315 miles, that is, not far short of the total coast line of the island. The more recent operations have been completely successful, as the locusts that appeared last year were comparatively few in number, and did no appreciable damage, and any future visit may be looked forward to with complacency. A full account of the improved system will be found in the pamphlet published by Messrs. Sprague and Co., entitled "The Locust War in Cyprus," and written by Mr. Brown, the Government engineer. There is also a model and full-sized trap in the Cyprus Court.

FORESTS.

But the forests of the island also demanded attention. The long-continued ignorance and indifference of both the people and their rulers had been attended by such a wholesale destruction of trees, as already had the most baneful effects on the agricultural prosperity of the island. Under such treatment the splendid pine forests were gradually disappearing. A careful examination of the best preserved parts of the forests showed that for every hundred trees which were standing, seventy-two had been felled, and allowed to lie rotting on the ground, while there were only twenty-five seedlings to the same proportion. The soil of the hills in which they formerly flourished, was gradually washed down to the plains, where it choked the rivers, and became transformed into malarious swamps. The hills, becoming bare and barren rocks, were taken possession of by the locust, with the result we have already seen. This was the process which we found going on when we arrived in Cyprus. Evidently no time was to be lost in the adoption of remedial measures.

The attention of the Government was at once given to the subject. The forests were placed under control, and the destruction of wood prohibited, moderate supplies being permitted for native wants. Two English superintendents were immediately appointed, with a number of men to take their instructions, and the reports of experts were obtained with all possible speed. Mr. A. E. Wild, Deputy-Conservator of Forests, from India, surveyed the forests on the south and west of the island, and made an interesting report on the subject, in which he recommended among other things the introduction of the eucalyptus plant. In 1880, the services of M. Madon, of the French Forest Department, were placed at the disposal of the authorities by the French Government, and this gentleman, who possesses an accurate and extensive knowledge of forest science, has furnished a valuable report with regard to their conservation. M. Madon ascribes the chief dangers to the forests to arise from the reckless customs of the people, the prevalence of the practice of clearing tracts by firing the timber, and the uncontrolled pasturage of goats. The system of prosecutions adopted by the authorities will, in time, prevent damage by either of the two first contingencies, while a heavy impost on goats was recommended for the purpose of checking the depredations of these animals which are found most destructive of young trees, and are much complained of for the injuries they cause to the vine and the wild carob. But, further, the delimitation of State forests is now progressing rapidly, the indiscriminate pasturage of goats has been stopped, the forest area enclosed being divided into blocks in which plantations are to be reared in such an alternation that young trees may grow high enough to preserve them from destruction before animals are allowed to graze in their midst. And, meanwhile, all forest produce is admitted into Cyprus free of import duty. A large number of trees have also been planted at considerable cost, the chief species being Aleppo pine, cypress, carob, œlanthus, oak, mimosa, eucalyptus, and *Pinus pinea*. The eucalyptus, so desirable from a sanitary point of view, has met with very uncertain success. A new introduction is the mango seed, never before planted in the open air in the Mediterranean. The recuperation of forests, however, is a work of time, but so far, this branch of the administration has had the careful attention of the authorities, the good results of whose efforts will be more and more manifest in each succeeding year.

What, then, was the condition of the island at the time of the occupation? We found an incompetent and to a great extent an irresponsible government, a vexatious and ruinous system of taxation, an unstable currency, an utter neglect of forest cultivation which threatened to convert the island within a very short time into a desert tract, inasmuch as the rainfall, which is so largely influenced everywhere by the cultivation or neglect of arboriculture, had been steadily decreasing; an increase in the locust pest which had assumed alarming proportions, and a population indebted and despairing. But there was one blot in the administration of the island which perhaps was more detrimental to its future progress than any other, and that was the condition of the courts of law. Although the Turkish law, founded as it is on the Code Napoleon, is admirable in theory, it is utterly inefficient in practice. Most appeals to justice were decided not on the merits of the case but on the length of the purse strings, and the members of the various law courts were, as a rule, totally unfitted for their position. It is only fair, however, to say that bribery in

Cyprus, as in the East generally, was an understood thing in legal transactions as in all others, and the wretchedly insufficient pay of the officers formed some excuse for them.

THE COURTS.

The courts were four in number, viz., the Medjliss Temyiz and the Medjliss Daavi, the Tribunal de Commerce of Larnaca, and the Mekkêmé-i-Shéri, or Mussulman Religious Court. Of these, the two former fall properly under one head, the Daavi being the inferior while the Temyiz was the Superior Court and Court of Appeal. In each district there was a Medjliss Daavi, the court being composed of a cadi as president and four members—two Moslem and two Christians—and having a civil jurisdiction without appeal up to 5,000 piastres, and a criminal to the extent of passing sentence for as much as three months' imprisonment. The Temyiz held at Nicosia consisted of a cadi and six members, three Moslem and three Christians. This was the Superior Court. The fountain of justice was, however, centred in the person of the Governor. An action in the inferior court could not be initiated without the fiat of the *kaimakan*, nor could the judgment be enforced except by consent of the same authority. The Temyiz, in like manner, only adjudicated on causes remitted them by the *mutessarif*, and their decision also was subject to his control. True, this permission to litigate was, as a rule, easily obtainable, the stamp duty being only one piastre, but it illustrates curiously the despotic theory of Turkish government. In criminal cases sentences of the Temyiz, when involving imprisonment for over three years, required confirmation by the Governor-General of the Vilayet or at Constantinople. With the exception of the cadis, the inferior judges were illiterate men They were, in addition, wretchedly paid, and the administration of the law was a matter of much complaint among the natives. A field for reform was therefore open in this direction which speedily engaged attention. After lengthened correspondence and discussion between the representatives of the Queen in the island and the authorities at home, a complete reorganisation of the department of law and justice was resolved on, and carried into effect in 1882, following upon an Order in Council. The most salient features of the scheme were the formation of a Court of Appeal, composed of two qualified English judges, the appointment of an English judge to preside in every district, and the establishment of a number of village judges to deal with petty civil cases. It included also the adequate payment of the native judges, although their number was gradually reduced to a considerable extent, and likewise established a system of jail deliveries by judges on circuit similar to that which prevails in this country.

By special provision in the Convention, the Mussulman Religious Court was allowed to remain. Its proceedings were, however, restricted to purely religious questions affecting Moslems alone.

This reform of the law has been attended by a great decrease in the number of vexatious prosecutions and trivial actions, with which, in the former uncertain state of affairs, the Courts were very frequently troubled.

I may here quote the words of Sir Robert Biddulph :—

> "The change that was effected in the judicial system in 1883 may be truly characterised as stupendous. It was effected without friction or any material difficulty, and has placed the courts of Cyprus on a footing hitherto unattained in the eastern parts of the Mediterranean. Not the least satisfactory result is that the judgments of the courts are received by the people with implicit confidence, whilst the best testimony to their efficiency may be found in the fact that their work, which is heavy and continuous, proceeds smoothly, and hardly attracts public attention."

These, then, were the great reforms brought about by English administration. Still it is only right to mention that a great deal has been done to open up the country by the making of roads, which practically did not exist before, by the erection of piers, jetties, and bridges, by improved irrigation works and by affording education as well as proper medical treatment to the people ; and by the establishment of an efficient police and proper jail accomodation ; by a complete survey of the island, of which a map hanging on the wall, prepared by Colonel Kitchener, is the result, and by many other minor reforms which I might refer to, had I time.

PRODUCTS AND INDUSTRIES.

Let us now consider the products and industries of Cyprus. As regards its minerals, for which in former times it was so famous, we must await a more detailed investigation before speaking confidently about them. There is a very fair show of these in the Cyprus Court. At the present time several concessions have been granted for working the copper and other mines in the western and south-western portions of the island. I may, however, quote, as a proof of the excellence of these minerals, that, since they have been on view in the Cyprus Court, we have had an order for fifty tons of *terra umbra* from a gentleman who declared that it was of exceptionally fine quality.

The wealth of the island, such as it is, consists in its agricultural produce, chiefly corn, cotton, carobs or locust beans, olives, silk, or wine. When we remember that not much more than a third of the island is under cultivation, and that even the rocky barren portions, where the locusts are wont to breed, are specially adapted for the cultivation of the carob tree, it can easily be realised that all these products are capable of being largely increased, and consequently of enriching the people. It should also be borne in mind that the system of agriculture in use is still of an extremely primitive character. So rich is the soil, especially in the great Mesaorian plain, that it never needs manuring, is scratched rather than ploughed, and yet produces wheat of the finest quality, and very often double the quantity of that yielded by good English land. The average rainfall not being much more than twelve inches in the year, the success of the grain crops depends to a large extent upon the overflowing of the rivers into the irrigation canals once or twice during the season. These so-called rivers are merely dried-up beds, running only after the heavy rains that occasionally fall in the mountain ranges. Bearing these facts in mind, let us examine into the statistics of exports and imports, expenditure and revenue, and see whether the island shows any moral and material progress since the British occupation.

In 1878, out of a total export trade in the hands of the island of about £157,000, 20 per cent. consisted of carobs, and nearly the same quantity of wine, the corn crops of that year being exceptionally good, and accordingly yielding an export of almost equal per-centage, although next year they diminished by five-sixths. Under the favouring auspices of British rule, almost every industry began to show very perceptible increases. The abolition of the tithe farming system, and the adoption of the more generous as well as more politic measure whereby the agriculturist was permitted to deal with his crop as he pleased, the collection of the tax being delayed till a later season, when he should have had ample time for the conversion into money of the produce of his holding, had a most favourable influence on the particular industries affected, and consequently on the trade of the island generally. The volume of foreign trade, which in Turkish times was estimated at £1 10s. per head of the population, amounted, in 1879, to £2; in 1880, to £2 10s.; and in 1881, to £3 per head, since which time steady increases have been recorded. Both imports and exports for the year following the British occupation were largely augmented. A diminution in the exports which occurred in 1880 was due to the want of rain and consequent failure of the crop, and does not affect the general statements as to the beneficial results of the new system. From that time till the present remarkable strides have been made in both branches of commercial activity; but it is worthy of note that, alike in imports as in exports, there appears a decrease for the year 1884-85. The decrease in the exports, which is very small, may, however, be looked upon more as a matter of figures than of reality, for the wine crop in that year, to take an instance, was the largest yet known, showing an increase; but the price realised was exceptionally low, and the same may be said with regard to the values of the cereals. The decrease in imports nearly amounted to £40,000, and though the gross amount was less than that for either of the two years immediately preceding, yet it shows a considerable balance over the imports for 1881. It would therefore seem that it must be attributed to the overstocking of the market, a state of matters which will in course of time provide its own remedy. The nett result of British occupation to Cypriot commerce may be very fairly estimated by a comparison of the respective imports and exports for 1878, the last year of Ottoman rule, with those of 1884-85. The imports for 1878 were £177,651; for 1884-5, £304,375. The exports in 1878 were £157,328; last year they amounted to £287,521; and the figures were still higher the year before, especially as regards the imports.

A glance at the progress made in one or two of the different articles of export may still further accentuate the change for the better that has taken place within the last seven years. In 1878, the exports of carobs amounted to £29,971; the following year, through an abnormally good harvest, a large increase was recorded, bringing the exports up to £85,345. In 1884-5, however, they reached £92,516, being the best crop known as yet. The wine export of 1878 was slightly over half a million gallons, valued at about £25,500. The returns for 1884-5 give an amount exported of 1,396,847 gallons, representing a value, notwithstanding a considerable fall in prices, of over £45,000. It is interesting to note that the quantity of wine manufactured in the same year was not much under 2,200,000 gallons. The exports of cotton, raw and manufactured, worth in 1878 something over £13,000, are now more than doubled.

While the trade of the island generally has thus increased, the trade with the United Kingdom has likewise been augmented. At the present time it is more than double what it was in 1879. The exports from this country include copper manufactures, rice, cotton yarn and piece goods, iron and steel, and silk and woollen manufactures.

Revenue.

When the trade and commercial economies of a country are in a flourishing condition, its contributions to the Imperial Revenue may be expected to share in the general weal. Since the British occupation of Cyprus, where alteration has taken place in the various imposts, it has always been for the benefit of the taxpayer, yet the revenue has steadily risen year by year, only excepting last year, when, in common with Cypriot commerce generally, it showed a decrease, accounted for by the dullness of trade, the low price of cereals, and the abolition of the grape tithe. In each year the Government accounts have shown a surplus, which was as low as £6,000 in 1881-2, but reached £82,000 in 1883-4. These surpluses, however, have hitherto proved inadequate to meet the payment of the tribute to the Porte, £92,800, and it seems hard that a fertile and prosperous island should be saddled with a burden of this description. Formerly, when in Turkish hands, Cyprus was governed by an administration headed by a pasha, at a total cost less by two-thirds than Great Britain has found it possible to expend, dealing justly, but not by any means too generously, with the people. On the other hand, by the exercise of extortion and oppression, coupled with what can only be called administrative senility, the Ottoman Treasury extracted from an impoverished population a revenue considerably less than the people, under a proper system, have shown themselves able to pay. But to rule the country well, for the good of its inhabitants and in accordance with the traditions of Great Britain, and in addition to pay to the Sublime Porte the full amount of surplus which it in former times was able to obtain, is certainly at present too much for the resources of the island.

In comparing the amount of revenue and expenditure, one thing more should be taken into account. On the transfer of a province from Mussulman to British hands, much would naturally require to be done on the score of what may be classed as public works. The locust war, the timber precautions, and tree cultivation I have already alluded to, but in addition roads, bridges, and jetties have been constructed, public buildings, prisons, and hospitals have been erected, and a trigonometrical survey has now been completed; but the cost of all these improvements, save one, has been included in the ordinary expenditure, and still leaves the noteworthy surplus to which I have referred. The single exception was due to the very heavy expenses connected with the locust campaign, which demanded an advance from the Imperial treasury. But this necessary debt is now in course of rapid liquidation.

If we compare the trade statistics of the various British Colonies for the last ten years, we find that, whereas in many important Colonies there is a decrease, in the case of Trinidad alone does the increase exceed that recorded in respect of Cyprus, which for seven years shows an increase of 76 per cent., while Trinidad for a period of ten years shows 86 per cent.; and we may confidently expect that, with improved methods of grape cultivation and in the making of wine, as well as in agriculture, and a constantly increasing area under cultivation, this per-centage will grow higher every year.

It is true that, in order to meet the burden of the payment to the Porte, and the expenses of first installation, grants in aid have been made to Cyprus, amounting to about a quarter of a million of money during the last six years; but in view of the steadily increasing prosperity of the island, and the remarkable decrease in the amounts of these grants with each succeeding year, we may reasonably hope that the time is not far distant when they will not be required at all. In 1882-3, £90,000 was granted. In the next year £30,000, and in the last two years only £15,000 each year. Were it not for the fact that the payment to the Porte represents a tax equal to half the average revenue, grants in aid would never be required.

Let us for the moment forget that the island has to pay £92,800 out of its revenue, and compare the total amount of revenue and expenditure for the last six years; and we shall find that the proportion of revenue to expenditure is for that period £1,023,644 to £738,939, or, roughly, as 100 to 70, giving an average surplus of £47,450, and in no case has the expenditure exceeded the revenue, but, on the contrary, even in bad years been considerably under it. And in good years the revenue has borne the proportion of 8 to 4½, or very nearly double. These figures are, to my mind, extremely significant, in view of the resources and capabilities of the island, hitherto but partially developed.

In what I have said this evening, I have endeavoured to stimulate inquiry and attention rather than to satisfy them, the limited time at my disposal rendering an exhaustive treatment of the subject out of the question. It seems to me, however, that it would be as well that I should state what in my opinion remains to be done, in order to enable the island once more to return to its former wealth and prosperity; and in any discussion that may arise on the paper, I trust that you may have the benefit of the views of men far more experienced than myself. Putting aside all minor improvements in developing such industries as cereals, grapes and carobs, it seems to me that there are three things which yet remain to be done. The first is to become the purchasers of the fee simple of the island, instead of being tenants at will, as we are at present. The second is to spend money, even to the extent of getting into debt, in order to plant the mountain ranges, and especially the northern one that runs down the Mesaorian plain; and the third is (again getting into debt if necessary), the establishment of a railway from Morphou to Famagusta, leaving its after development to time, and to put the harbour of Famagusta into proper repair for mercantile use, both of which latter schemes could be done at an expenditure which would be trifling in comparison with the advantages that would almost immediately result. If the first of these could be done, viz., the doing away with the payment of the tribute by the purchase of the island outright; the second could be effected out of the current revenue; and the third, viz., the railway and port, by means of a loan, about which there would be no difficulty, inasmuch as the position of the island would be assured instead of uncertain as it is at present. It matters not whether some of us regret, whilst others applaud, the acquisition of Cyprus. One thing, however, is certain, and that is that we can never leave it. We have done a great moral good to an oppressed and long-suffering people, and under no circumstances could we now retire without committing a great moral wrong. Supposing that we bought the island at sixteen years' purchase we should have to pay £1,484,800. Now I have already pointed to the fact that the surplus of revenue over expenditure during the last six years has amounted to £284,705, or an average of £47,450 per annum, which represents a capital of £1,486,200, in other words about £2,000 more than the supposed purchase money, so that the island Government would be justified on past experience in raising the loan even if they did not rely upon the strides that would result from the removal of the burden of payment to the Porte. But there is another aspect to this question, and on this point I should particularly like to have the opinion of men like Sir Robert Biddulph and Mr. Hamilton Lang. Have we not a right to ask for a considerable reduction in the purchase-money as compensation for improvements in the widest interpretation of the phrase, and also in view of the circumstance that the amount of tribute we have been annually paying was over-estimated, to say nothing of the fact that it did not represent good money, but paper and debased coinage? The saying that he who goes a-borrowing goes a-sorrowing, though true of persons, is certainly not true of peoples. Where would the world be if the principle had been followed out?

With regard to the second point, I am sure you will bear me out that it is now an established axiom that climate is influenced to an extraordinary extent by the presence or absence of forests. I need only refer to the remarkable changes, not only in the seasons but in the direction and character of the wind and the amount of rainfall, within the memory of man even, in the United States, as an illustration; or, again, to the replanting of the Alps by the French Government, by which the floods that devastated the country at uncertain intervals have ceased and a steady rainfall taken their place. As an illustration on a small scale may be cited the cutting down of the forests round Ravenna, which resulted in the appearance of the *khamsin* or desert wind, which had never blown before, and which again disappeared when the forests were replanted. M. Madon, under whom I worked in the Forest Department when he was principal Forest Officer in Cyprus, and who is one of the ablest and most scientific officers in the French service, assured me that, for a comparatively small expenditure spread over the time, he could double the rainfall in Cyprus in twelve years. This fact speaks for itself, and would justify a loan, though I do not think it would be required supposing my first proposition was carried out. A railway could be laid down at very little cost, as the great plain is as level as the plains of Saxony, and, as will be seen by reference to Mr. Ormiston and Mr. Brown's reports, very little would be required in comparison with the benefits accruing to bring the harbour of Famagusta, which is double the size of Valletta, into good working condition.

In thanking you for the attention which you have given to my paper, I can only express a hope that the progress achieved, which is almost entirely due to the untiring energy and administrative ability of Sir Robert Biddulph, will bear fruit, by awakening an interest in the Island of Cyprus in the minds of the British public, and so leading them to add one more colony to those we already possess.

APPENDIX.

CYPRUS PARLIAMENTARY PAPERS.—1878–1884.

1878.

C.—2057..........Anglo-Turkish Convention.
C.—2090.......... ,, further correspondence.

1879.

C.—2223..........Public Works Ordinance (freed labour).
C.—2224..........Anchorages.
C.—2229..........Correspondence.
H. of C.—151......Troops and sickness.
H. of C.—169......Health of troops report.
Second part of 151..Further as to health of troops.
C.—2324..........Complaints against the local government.
C.—2351..........Certain ordinances.
C.—2355..........Complaints. Further correspondence.
C.—2394..........Estimates of revenue and expenditure.
C.—2398..........Treatment of prisoners at Famagusta.
C.—2425..........Public works aud English *employés*.
C.—2427..........Forests.

1880.

C.—2542..........Public works.
C.—2543..........Annual reports.
C.—2544..........Famagusta harbour.
C.—2628..........Payments to the Porte.
C.—2629..........Financial state of the island.
C.—2699..........Lists of *employés*.

1881.

C.—2930..........Correspondence. Affairs of Cyprus.
C.—2991..........Application of surplus revenue (tribute).
C.—3005..........Finances of Cyprus.
C.—3091..........Further correspondence.
C.—3092..........Annual report of Commissioner.

1882.

C.—3211..........New legislature.
C.—3383..........Finances.
C.—3384..........Further correspondence.
C.—3385..........Annual report.

1883.

C.—3661..........Finance and administration (Mr. Fairfield's mission).
C.—3662..........Finance.
C.—3772..........Annual report.
C.—3791..........New constitution.

1884.

C.—4120..........Reduction of the grant in aid.
C.—4188..........Annual report.
C.—4189..........Locust campaign.
C.—4264..........Census of 1881, report.

1885.

C.—4435..........Revenue funds.
C.—4438..........Revenue and expenditure.
C.—4471..........Further as to the above.
C.—4585..........Further as to the revenue funds.

1886.

C.—4620..........Locust campaign.
C.—4694..........Annual report, 1884-5.

DISCUSSION.

Mr. **HYDE CLARKE** remarked that it was not desirable to criticise too closely the political portions of Mr. Gordon Hake's paper, as such were matters of controversy, and there were other topics of more importance treated by Mr. Hake which more immediately affected the objects of the Society. At the same time he might say he was not able to confirm some of the doctrines of Mr. Hake. Andalusia furnished an historical example of a country in a condition of prosperity under Mussulman government, so that Mussulman government was not to be taken as an infallible and necessary indication of ruin. His own connection with Cyprus being in the capacity of Councillor for Cotton Culture, he could not recognise that any doctrine of fatality prevented the extirpation of locusts in the East. The extirpation of locusts was an ancient institution in China, imitated in Turkey and Russia. The United States imitated the Russian system, but it had been found lately that a mixture of bran, syrup, and arsenic was effective. It did not appear that the failure of timber in a country was any cause for creating locust-breeding grounds, either in Asia or America. The destruction of forests in Cyprus is not more a cause of reflection on a Government than is that of the destruction of forests in India on our Government, and that of the neglect of timber in our own islands. Government forestry has only lately been taken up by our administration, or by the Turkish. The true lesson to be derived from the valuable paper of Mr. Gordon Hake is that each administration should depend on its own merits, and every effort should be made by our present Government in Cyprus to apply every measure of progress for the advancement of the island of Cyprus and its population, not forgetting that the Government should, so far as is possible, conduct the administration in conformity with the habits and wishes of the population. Mr. Hake had referred to the conquest of Cyprus by King Richard as an incident in English connection; but it was curious that at that epoch the intercourse was not so restricted. Beside the history of the Waranghian guard, which was an English body, there were many English crusaders who visited the island. The ruins of the English church still remain, and the establishment of a new English church may be regarded as an indication of the resumption of this hereditary intercourse. It would be interesting if monuments were put up in that church to De Ros and other English crusaders.

Mr. HAMILTON LANG said that he had listened with much interest to the paper of Mr. Hake, having spent ten years in Cyprus. The progress which had been described by Mr. Hake was considerable, the chief features being, the destruction of the locusts, the establishment of a good system of justice, and the restriction on the destruction of the forests. The difficulties of the work imposed on our administrators, in the first years of the administration, could only fully be realised by one who had been obliged to master the details of administration in an Eastern country, details which they could only get through interpreters incompetent to give them, and on subjects totally novel to the Western mind. When he visited the island last year, after fourteen years' absence, nothing gave him greater pleasure than to notice the progress which had been made in one direction which Mr. Hake had not alluded to, being an example of it himself, and that was in our officials becoming able to do their work without the aid of interpreters. He found a large number of British officials, especially those engaged in the administration of justice, who had acquired sufficient knowledge of the language to treat directly with the natives; this was an immense step, the results of which would be seen in the future, It was only through direct relations that you could enkindle sympathy between the governed and the governing, and only in that way could the higher officials use the more economical materials around them for the subordinate offices of the Government. No people were more susceptible to these direct influences than the Cypriots. When a peasant could tell his tale in his own language to his superior, he felt he had a fair hearing. He was delighted to hear, in Cyprus, encomiums passed on the administrators who were able to talk directly with the natives, and through them the natives got to understand the honesty, impartiality, and devotion, which characterised the English. The Chairman must excuse his repeating in his presence what he had often said before, that in his six years' administration of the island he gave the highest example of these qualities. The men who worked there so laboriously deserved the utmost sympathy and honour, all the more because of the exceptional difficulties in their way, and the ungrateful character of their work, on account of the heavy burden of tribute. They were a good deal like the Israelites in Egypt, who had to make bricks without straw. To show how heavy was the burden of taxation, he would compare it with that of one of our own colonies. In New South Wales the export trade was about £13,000,000 sterling per annum, while its taxation amounted to £3,000,000. In other words, the taxation was about one-fourth of the money received from abroad through its exports. In Cyprus, £180,000 was taken out of the island in taxation, and the export trade was only £280,000. Thus, over and above every £1 of taxation taken from New South Wales, £3 was received from abroad; whereas in Cyprus, over every £1 of taxation only 11s. was received by the island. The consequence was that capital did not accumulate; if it was not killing the goose which laid the golden eggs, it was starving her so that she could hardly lay an egg at all. The great benefit of this paper was that it showed the necessity of doing something to ameliorate this condition. The three remedies suggested were the purchase of the fee simple, the construction of a railway and harbour, and the extension of forests. He quite agreed that something should be done to relieve the island of some portion of the tribute to the Porte, but with regard to the purchase proposed he feared great difficulties would be raised by the British Treasury. The tribute was not paid to the Sultan, but was retained as part payment of the loss sustained by England and France in paying the deficiency on the guaranteed Turkish loan of 1855, of five millions. That loan required £160,000 per annum for interest alone without any sinking fund; £70,000 was obtained from Egypt, and the remaining £90,000 had to be paid by England and France; and to meet this the tribute from Cyprus came in. Therefore not only England but France would object to giving the Sultan anything as an equivalent for the tribute of Cyprus. He had thought a good deal on this subject, and the plan he should prefer was this. To pay off the £3,700,000 remaining of the Turkish loan, by borrowing a similar amount at 3 per cent., plus ½ per cent. for a sinking fund; £130,000 per annum would be all that was thus required. Towards that there would be the £70,000 received from Egypt, leaving only £60,000 to come from Cyprus, or an economy of £30,000 a year, which would be a great relief to her, and also to the British taxpayer, because at present Cyprus could not pay the £92,000, and a grant in aid had to be made every year. With regard to the construction of a railway and harbour, they were both very desirable, especially the latter, for at present you could never be sure of getting into or from the island. Last autumn some friends of his were coming from Beyrout to Larnaca by a French steamer; they arrived, but could not land, and were carried off to Alexandretta, where they had to pay £50 to a little English steamer to bring them to Larnaca three days later. A harbour existed at Famagusta almost ready to hand, it was nearly as large as that of Valetta, and could be cleared out for £60,000. With regard to the railway, it could be easily made, of a narrow gauge, for £140,000, so that the two works could be undertaken for £200,000. But he thought private enterprise was more economical and succeeded better in these matters than Government administration, and he should prefer that the Government of Cyprus merely gave a guarantee of 4 per cent. on the capital. The whole burden would be £8,000, even assuming nothing was got out of it, which was not possible. He looked more and more to see British capital interested in the island, as that which was most of all required. With regard to the extension of the forests, as Mr. Hake had said, that would increase the rainfall, which was the greatest desideratum. When he was in the island, the largest rainfall was 16 inches, and one year it was only 6 inches. Under such circumstances, there was not much prospect for agriculture. But even without planting on a large scale, he had not much fear of the extension of the forests, especially since his last visit, when on one hillside he was shown by a peasant that half of the trees were of four or five years' growth, which he told him would not have been there but for the restrictions imposed by the Government. The extension of a forest was like the growth of compound interest, one seedling gave in a few years a dozen, they gave a hundred, and so you soon got to thousands, if nature was not interfered with. In the past she had been interfered with, both by goats and by man, but the natural growth would now increase year by year, and soon produce an effect on the rainfall. The growers of grain especially suffered, because not only had prices fallen, which had been equally a source of great loss in England, Ireland, and all European countries, but in Cyprus the value of labour had been rising at the same time. There would, therefore, be a great advantage in relieving the burdens on the culture of grain, and this could only be done by reducing the tribute. If this were done, the protection of the forests persevered in, and efforts made to stimulate useful public works, in ten years time Cyprus would be a dependency of which all Englishmen might be proud.

Mr. J. H. KERRY NICHOLLS said he had visited Cyprus during a yachting cruise in the Mediterranean a few months before it was taken over by Great Britain. Of its fertility and mineral resources there could be no doubt, in the past, and he ventured to think they would exist also in the future. The very name of the island linked her to the great empires of the East, and took one back to the golden age of mythological romance. In fact the moment one landed one was reminded of the beautiful words of the poet—

> "Poetic scenes encompass me around,
> And still I seem to tread on classic ground,
> For here so oft the muse her harp hath strung,
> That not a mountain rears its head unsung;
> Renowned in verse each shady thicket grows,
> And every stream in heavenly memory flows."

Every visitor could see the remains of its ancient cities and ruined temples, and the traces of its past magnificence and wealth. In a journey from Larnaca to Nicoseia he was much struck with the apparent want of energy of the people, but they were not then under the influence of Great Britain. The fields were uncultivated, though the soil appeared to be rich, and though the forests had been denuded, the remaining trees showed a strong and vigorous growth. He was much surprised to hear that the eucalyptus did not do well there, as he had found it in all parts of the world, in Egypt, Ceylon, Japan, China, the United States, and in France, Spain, and Italy. The mines he thought would be found worthy of more examination and development. The locust pest was found in various parts of the world, notably in some districts of Australia, where the bush turkey had been found useful in destroying it. The question of purchasing the fee simple of the island was a very important one, and he thought the British Treasury would always open its coffers where there was a distinct advantage to be gained. The importance of the island to Great Britain could hardly be over-estimated. It formed the guardian to the Suez Canal; it commanded the important isles of the Ægean Sea; and with those islands in the possession of a maritime power she could hold the Dardanelles, and thus command almost the heart of Europe. But the safety of the canal was quite inducement enough, and considered in connection with Malta and Gibraltar, the final acquisition of Cyprus by Great Britain was of the greatest importance. Then there was another consideration. The construction of a railway by the valley of the Euphrates was not altogether a chimerical idea, and for such an undertaking Cyprus was an important *point d'appui*. At no distant time, he believed the Euphrates railway would be linked with one in Asia Minor, and thence to the railways in Europe, and it would finally pass through Beluchistan to India, and from there to Cape Comorin. The time would come when Australia would be linked to Cape Comorin by a line of steamers, and in this way, by one continuous route, Australia would be within three weeks' journey of England. With regard to the cultivation of grain, he thought that, owing to the competition of America and India, the days in which grain could be profitably grown in Europe had passed, but it struck him that Cyprus was a magnificent country for the cultivation of the vine. In former ages Cyprus gave wine to the gods, and why should it not continue to give wine for man.

Captain TALBOT HARVEY, bearing in mind the example of the Ionian Islands, feared that even if the fee simple of Cyprus were purchased, pressure would at no distant date be brought to bear to hand it over to the Greeks. He thought the feeling of uncertainty on such grounds had a great deal to do with the reluctance to invest capital there. If the fee simple were acquired, England could deal with Cyprus as she liked, and the question with him was whether it was not better to let things remain as they were, when nothing of the sort could take place without the consent of Turkey, which she was not likely to give. So long as we retained possession of the island, and went on developing its resources and improving the condition of the people it was all right, but if we had unlimited control over it, somebody might want to hand it over to Greece, and he thought the last speaker must know the immense difference between the state of the Ionian Islands now and when they belonged to England.

Mr. TRELAWNY SAUNDERS said he should like to refer to a point which had not yet been touched upon, namely, one of the conditions in the treaty by which Cyprus was handed over to Britain. By that treaty Turkey undertook to reform its government on the mainland; but though we had been so long in the occupation of Cyprus, and our administration had been so successful, and though a number of highly qualified gentlemen under Sir Charles Wilson had been sent to Asia Minor to report on the state of the administration, the only result had been the reports which were duly pigeonholed in the Foreign-office. The country was as deeply interested in the good administration of Asia Minor now as it was when the treaty was signed, and it was not a question merely of sentiment, it affected the material prosperity and trading interests of our people. It was a loss to the world at large that the provinces of Turkey were maladministered. The result of our experiment in Cyprus showed that good administration alone was required to restore to the various parts of the Turkish Empire the fruitfulness they formerly possessed. Turkey swept away the marble cities of Asia Minor, and left them in ruins, and so they remained. It was a serious question for all Governments which had an industrial population to look after, what should be done. He hoped the engagements of Turkey, under the treaty, would not be lost sight of. Liberal politicians in England thought everybody was qualified for representative Government. He would not ask the Chairman whether he had advised the introduction of representative institutions into Cyprus, but he should like to know whether the experiment had been satisfactory. He thought our administration of Cyprus had been undeniably successful, but it was the fashion with some to say we should retire from everything, and in fact do nothing whatever except through the agency of missionaries. His view was that we had done more good in Cyprus than had been done by missionaries all over the world. The public were not entirely blind to what had taken place in Cyprus, and the results which followed our occupation would have a great effect on our influence in the East. All these advantages, however, had taken place under a military governor, and Cyprus was occupied primarily as a military measure; but now he much regretted to see that he had been replaced by a civil governor.

The CHAIRMAN, after remarking on the valuable character of the paper, said there were one or two important points prominently brought forward, on which he might be expected to say a word. First, with regard to the purchase of the fee simple of Cyprus; that was not a very good expression, nor was there any probability of its being carried out; if any such idea took shape, it would rather consist in commuting the tribute. In this case, the island would remain Ottoman territory, but in the other, it would become British, and the great objection to this was that the Turks never would agree to it, except under some extraordinary combination, such as a war with Russia, in which we were the allies of Turkey. He had reason to know that the Sultan was extremely jealous of his dominions, and that he had some regrets at having alienated Cyprus. The commutation, or capitalisation of the tribute was another thing; it would not affect the sovereignty of Turkey, nor her right to have back the island in certain eventualities, contemplated in the Convention of 1878. This subject had engaged his attention a good deal, though he could not say it had much engaged the attention of the British Government. He thought sixteen years' purchase would be too large a sum to pay, and Mr. Hake's figures proved it, as they showed that the average surplus would be just sufficient to pay the interest, so that the island would not be appreciably benefited. Mr. Lang had had great experience in the East, but the difficulty which suggested itself in the way of dealing with the matter in the way he had suggested, was that when the Turkish loan of 1855 was extinguished by the operation of the sinking fund, the rights of the Turks would revive, and they would again call for the payment of the tribute.

Mr. LANG said he should be quite willing to abandon the sinking fund, which would be a further relief to the island.

The CHAIRMAN said the 1855 loan had no necessary connection with Cyprus; it was a mere coincidence that the tribute was devoted to paying the dividends upon it, and he did not see why Cyprus should not stand on its own basis and make a bargain with Turkey, commuting the tribute at ten or twelve years' purchase, and with a moderate sinking fund the whole thing might be cleared off in thirty years. The difficulty of course was to upset any arrangement once made, and at present we paid half to France, as joint guarantor of the loan, but if we chose to say, as guardians of Cyprus, that we would not do this any longer, and that we must get the dividends as best we could from the Smyrna customs or Egyptian tribute, he did not see that France would have any right to object. It was said that if the loan were once paid off the question of cession to Greece would be sure to be raised, and no doubt there would be a certain amount of pressure put on from time to time in that direction, because the island once free would be a valuable possession; there would be a surplus which would be very valuable to any nation which did not, like England, leave her colonies to their own resources, but took any surplus revenue there might be from them. Whether the British Government would entertain any such idea, it was not necessary to discuss.

Captain TALBOT HARVEY asked whether there was not a feeling of uncertainty on this point in the island, which prevented the investment of capital.

The CHAIRMAN said there had been a certain feeling of uncertainty, not so much with regard to Greece, as because it was not British territory. English capitalists felt that it was Ottoman territory, and they did not know what might happen. It was almost impossible, he thought, under the conditions of the Convention of 1878, that the island should ever be retroceded to Turkey, because the principal Article was that this should take place if Russia gave back Batoum, Kars, &c., which was extremely unlikely. On the other hand, by another Article, Turkey undertook to reform the government of her Asia Minor provinces, which, as they all knew, had not been carried out. The Consuls were withdrawn for the simple reason that they could do nothing, and it was no use keeping them there to send the same reports year after year. With regard to the representative government given to the island, there was no doubt that some measure of the kind was necessary, not only to satisfy the people themselves, but also to satisfy public feeling in England. It was open to question whether it was not carried too far, and too large a majority given to the elected members of the council. There were six official members and twelve elected, and perhaps it had not been sufficiently considered that Cyprus was not a homogeneous country, like other colonies, where the electorate was in entire sympathy with the Government. The governors consisted of a small body of Englishmen, and the Electorate consisted of the natives who had only known them for a few years. Under such circumstances it was not to be wondered at that they should form a party by themselves, and try to carry any measure which they thought best suited to the country. It might be said they would know what was best suited to the country better than Englishmen, and in many respects they did, and their advice was extremely valuable, but on the other hand what would become of the reforms which were necessary. A nation could not remain for centuries under the deadening effect of the Turkish rule, and still retain their power of thinking and acting for themselves; if they did it would show that the system of government had not been so bad as was supposed. At the same time the establishment of the Legislative Council had had a very good effect in many ways. It had brought the elected members face to face with the Government, had opened their eyes and made them feel more respect for and confidence in the English than they did before. It acted as a safety valve, and though there were difficulties they had not proved insurmountable. Mr. Saunders had alluded to the fact of his having been succeeded by a Civil governor; as to which he could only say that her Majesty's Government had been actuated by a desire to select the best man for the place, and he was sure his successor would do his best for the good of the island. He was a man of high quality, and his previous history in the service of the Crown had been such as to justify every expectation that the interests of Cyprus would not suffer in his hands. He heartily endorsed Mr. Lang's remarks on the value of English officials being able to communicate with the natives in their own language. At the beginning the difficulties from this cause were enormous. Occasional mistakes were of course made, and there was no one to explain them; but natives soon found out that these mistakes were not wilful, and they were more astonished at the industry and zeal of the English than at anything else. He was much indebted on this account to that body of officials who worked with him in overcoming those preliminary difficulties. Every document was written in Turkish, which was not an easy language, and even of those who spoke it few could read; they were therefore entirely dependent on interpreters of Eastern extraction. And besides this, the Turks had carried away nearly all the documents, though in some respects perhaps, that facilitated a new departure. The replanting of the forests could not be accomplished without a great expense; but with careful conservation of the remaining forests that was not necessary. This was proceeding favourably, the main point being to keep the higher ranges from being denuded, for when this was accomplished, the soil was soon washed away, and there was nothing to replace it. The difficulties to contend with were, in many cases, raised by the inhabitants themselves, who thought their rights were interfered with, for though the Turks had good laws on the subject, they were never carried out. It was only by judicious management, tact, and perseverance, that they were able to preserve the forests at all; but when he left, things were getting into a fair state; all the disputes had been settled in favour of the Government, which had shown itself generous towards its opponents, and thus avoided any bad feeling. A small port at Famagusta could be made for £50,000, and this would be well worth doing, but with regard to the railway, he very much doubted whether it would pay its working expenses, and under such circumstances the Government could not be expected to guarantee a dividend. The island was small and sparsely populated, and there was practically nothing for a railway to carry. The question was carefully considered last year, when they were offered the Suakim railway for nothing, but the conclusion come to was that, even if laid down, it would not pay its working expenses. The railway must wait, he thought, until the island was more populous and there was more traffic. The establishment of the law courts had been a great success, and the quotation Mr. Hake had made from his report did not at all exaggerate his estimate of their importance. His great reason for urging this matter was, that as we had been for years urging through our ambassador the reform of justice in the Turkish tribunals, it would have been extremely illogical not to undertake the same thing ourselves where we had the power. There was some unavoidable delay at first, but the reform was all the more complete and successful when carried out. The Chief Justice of the island, who had now been there more than six years, had every reason to feel gratified with the complete success of the measure. He drafted the Order in Council, which was signed by her Majesty, and this had been admitted by lawyers to be not only a credit to the draftsman, but such a piece of work as had rarely been sent home from any colony. As regards public works, they did not exist prior to the occupation, and there were, of course, immense arrears to make up. First-class roads could not be attempted as yet, on account of the expense. All they could do was to make them fairly passable, but even this had led to an enormous increase in the number of carts. The only road when they went there was from Larnaca to Nicosia, and that had now been made a first-class road, well metalled, and with improved gradients, with the result that the fare by a vehicle had been reduced from 3s. 6d. to 2s. 6d., and the cost of transport by bullock cart, from 10s. or 12s. to 8s., besides which much heavier loads could be carried. The locust pest had been now practically put an end to, thanks to the thorough carrying out of Mr. Mattei's system, and the constant watch which was kept. After describing Mr. Mattei's system of screens, and the incident which had led him to devise them, the Chairman said much satisfaction had been given in Cyprus by her Majesty bestowing the Order of St. Michael and St. George on that gentleman, and he concluded by moving a vote of thanks to Mr. Hake.

The motion having been carried unanimously,

Mr. **Hake**, in reply, said he fully agreed with the Chairman that the inhabitants of Cyprus had nothing to do with the Turkish loan, and it was very unfai that the money should be taken out of the island on that account. Still he should not advocate anything which could be in any way be considered a breach of an equitable arrangement. Mr. Nicholl's suggestion of the introduction of the bush turkey might be worth considering, but, practically, the locusts in Cyprus were exterminated, the damage done by them last year not being more than £10. Captain Harvey suggested that after all Cyprus might be handed over to Greece; of course there was that danger, but we ought to go forward, trusting in the future, and not being held back by these uncertainties. He was very glad to find that he had the sympathies of gentlemen who knew the island, and if he had been too sanguine in proposing reforms, some of his suggestions at any rate had met with approval. With regard to replanting, he had referred particularly to some portions of the northern range, which was now almost entirely denuded, and he still thought money might be judiciously expended in planting there. Natives had told him they remembered when the whole of that range was covered with trees, where now there was not one to be seen. The rainfall would not be improved as quickly as it might be without some replanting, but he was glad to know that the Government was doing all it could to conserve the forests.

Miscellaneous.

COLONIAL AND INDIAN EXHIBITION.

The Conferences at the Exhibition were commenced on Friday last, 28th May, and several meetings have already been held, which were well attended. On Friday afternoon was held the first Conference of the Royal Colonial Institute, when a paper was read by Mr. F. B. Labilliere, on "Imperial Federation." On Monday, 31st May, Mr. P. L. Simmonds delivered a lecture on "Our Colonial Wool Supplies." On Tuesday afternoon, 1st June, the first Conference of the Anthropological Institute was held, the subject being the "Native Races in British Possessions in Africa." In the evening of the same day Mr. F. W. Pennefather delivered a lecture entitled "A Tour through New Zealand," which was illustrated by views thrown on the screen by means of the limelight. On Wednesday Mr. G. B. L. Druce read a paper on the "Importation of Grain and Bread Stuffs from the Colonies and India," and on Thursday, Mr. Arnold White read a paper on "South Africa as a Field for the Emigration of the Agricultural Classes." Each paper was followed by a discussion.

The number of visitors to the Exhibition for the week ending May 29th, was 160,170; making a total since the opening of 546,281.

ANIMAL FOODSTUFFS OF EGYPT.

The diet of the inhabitants of modern Egypt and the Nile valley does not embrace a great variety of meats. The consumption of butchers' meat is mostly restricted to mutton, and that only in small quantity. The flesh of the camel is eaten only by the peasants and desert Arabs, being unlawful for the Copts. Buffalo meat is tough, coarse, and seldom consumed. Pigeons and poultry are reared everywhere, and quails and partridges occur wild.

Fish figures largely in the maritime and fluviatile districts, the annual value of the fisheries of the country being placed at £125,000. The salt fish is prepared after the manner of cod; the smoked fish by the method adopted with herring. Small salted fish, known as "kishr" (*Perca nilotica*), are sold in barrels in the bazaars, and consumed in immense quantities. Another important item in the piscatorial harvest is "boutarge," a kind of caviare prepared from the roes contained in the two oblong, membranous pouches in the mullets common to Lake Menzaleh. The Nile fishes are insipid as compared with the sea kinds, though the "bultee" (*Labrus niloticus*), the "kishr" (*Perca nilotica*), and the "binnee" (*Cyprinus bynni*) are delicate flavoured. The natives have an objection to fishes which are unprovided with scales.

In Upper Egypt, crocodiles are taken in the Nile by means of traps, or by harpoons fixed in hollow bamboo handles, and secured by a cord which unwinds with the struggles of the wounded beast. This cord is made from the vascular tissue of the "ochar" (*Asclepias procera*), remarkable for the solidity of its fibre, of which is made all the cordage used on the Upper Nile. Honey is obtained from domesticated bees, and is generally clarified before being eaten.

BEETROOT SUGAR IN BOHEMIA.

Consul Hüning, of Prague, says in his last report on the trade and industries of Austria, that there are few countries in Europe of the same extent and population, for which the beetroot sugar industry has equal importance and significance as Bohemia. The Bohemian sugar industry is greater than that of all the other provinces of the Empire, Hungary included. Official statistics show that during the year 1883-4 the entire number of sugar factories in Austria-Hungary was 230, of which 152 were located in Bohemia, and that of the entire quantity of 41,845,679 metrical centners of beets on which a tax was levied before they were manufactured into sugar, 26,178,845 metrical centners were worked up in Bohemia. The bounty paid by Government in 1884 for sugar exported from the countries represented in the Reichsrath amounted to 23,313,468 florins, for sugar exported from Hungary to 1,011,877 florins, and from Bohemia alone to 19,977,000 florins, of which sum, 5,406,000 florins were for refined, and 14,576,000 florins for powdered sugar; while in 1883 the amount paid for bounties for exports from Bohemia was 17,184,000 florins. During the year 1884-5 there were in operation in the entire Austrian Empire 249 sugar factories, of which number 165 were situated in Bohemia. Of these 50 were owned by joint-stock companies, 3 by large corporations, 2 by the Bohemian Sugar Industrial Society, 60 by the nobility, 3 by the emperor, and the remainder by private individuals. During the year 1883-84 the number of persons employed in the sugar manufactories of Bohemia was 30,580 males, and 11,332 females, and in those of the entire empire of Austria-Hungary 46,683 males, and 20,024 females, whose daily wages average from 35 kreuzers to 1 florin (the florin being equivalent to 1s. 8d.). The Government tax on beets for the same period amounted to 20,942,535 florins for Bohemia, and to 33,476,543 florins for the whole of the empire. The extraction of the juice in the 152 factories of Bohemia was effected by the diffusion process, while the old method of employing grinding and powerful pressure was adopted at 12 factories situated in other parts of the empire. When sugar first became an article of export, the Government paid a certain bounty or drawback which, in 1860, was 5·16 florins on the centner of refined, and 4·20 florins on the centner of powdered sugar (the centner being equivalent to 220lbs.). In 1864, the bounty was increased to 6·51 florins on refined, and 5·30 florins on powdered sugar, and the bounty paid at present is 8·4 florins on the metrical centner of sugar containing from 88 to 92 per cent. of saccharine matter; 9·4 florins on the metrical centner of sugar containing from 92 to 99½ per cent. of saccharine matter, and 11·55 florins on the metrical centner containing more than 99½ per cent. The annual consumption of sugar in Austria is estimated to average twelve pounds per head, but in Bohemia, where coffee is in great demand, it is rather above this amount. The greater part of the sugar exported from Bohemia is sent by way of the Elbe to Hamburg, and from there to England.

Correspondence.

INDUSTRIES AND COMMERCE OF NEW SOUTH WALES.

In the instructive paper by Edward Combes, C.M.G., in the *Journal of the Society of Arts*, May 14, 1886, reference is made to "the remains of a struthious bird, named *Dinorsis Australis* by Professor Owen" (p. 686). The name given by me is *Dromornis australis*. I should not have noticed so trifling an error had it not been repeated at p. 688 and afforded no clue to readers wishing to refer to the original description of this extinct bird. My first paper thereon is given in vol. viii, "Transactions of the Zoological Society," p. 381, plates 62, 63; a second account of additional discoveries of remains of *Dromornis* in New South Wales is recorded in vol. x. of the same "Transactions," p. 186, plate 33. The substance of both papers form an appendix to the work entitled "Memoirs on the Extinct Wingless Birds of New Zealand," 4to, 2 vols., 1878.

RICHARD OWEN.

Sheen-lodge, Richmond-park, East Sheen,
21st May, 1886.

General Notes.

POPULATION OF ROME.—According to the latest statistics the population of Rome at the 31st December, 1885, was 345,036; at the 31st March of the present year it had risen to 349,921, showing an increase of 4,885 inhabitants.

INTERNATIONAL CONGRESS FOR PROTECTION OF INDUSTRIAL PROPERTY.—The third International Congress for the protection of industrial property was inaugurated at Rome on the 30th April. The Minister of Foreign Affairs, General Di Robilant, in his opening address, referred to the Convention of Paris of 1883 as not only of particular importance as the first concluded between the various countries of Europe for this purpose, but also because it may be considered as the first step towards the unification of the existing laws respecting patents.

MEETINGS FOR THE ENSUING WEEK.

MONDAY, JUNE 7...Colonial and Indian Exhibition, South Kensington, S.W., 4 p.m. Conference of the Anthropological Institute. "Native Races in British Possessions in America and the West Indies."

Royal Institution, Albemarle-street, W., 3 p.m. 5 p.m. General Monthly Meeting.

Engineers, Westminster Town-hall, S.W., 7½ p.m. Mr. R. P. Spice, "Some Modern Improvements in the Manufacture of Coal Gas."

Geographical, University of London, Burlington-gardens, W., 8½ p.m.

Victoria Institute, 7, Adelphi-terrace, W.C., 8 p m. Annual Meeting.

TUESDAY, JUNE 8...Colonial and Indian Exhibition, South Kensington, S.W., 2 p.m. Conference of the National Association for Promoting State-Directed Colonisation. 8½ p.m. Mr. Alexander Begg, "The Canadian North-West."

Society for the Protection of Ancient Buildings (at the HOUSE OF THE SOCIETY OF ARTS), 3 p.m. Annual Meeting.

Royal Institution, Albemarle-street, W., 3 p.m. Prof. A. Gamgee, "The Function of Circulation."

Medical and Chirurgical, 53, Berners-street, Oxford-street, W., 8½ p.m.

Gas Institute, 25, Great George street, S.W., 10½ a m. Annual Meeting. Inaugural Address by the President. Reading of papers and discussion.

Photographic, 5A, Pall-mall East, S.W., 8 p.m.

Anthropological, 3, Hanover-square, W., 8½ p.m. 1. Mr. C. H. Read, "The Ethnological Exhibits in the Colonial and Indian Exhibition." 2. Miss Buckland, "Indian Shell-work." 3. Mr. C. W. Rosset, "Ethnological Objects from Ceylon and the Maldive Islands."

Horticultural, South Kensington, S.W., 1 p.m. Show of Orchids.

Chemical Industry (London Section), Burlington-house, W., 8 p m. Dr. Meymott Tidy, "The Chemical Treatment of Sewage."

WEDNESDAY, JUNE 9...Colonial and Indian Exhibition, South Kensington, S.W , 4 p.m. Mr. L. J. Shand, "British Grown Teas."

Geological, Burlington-house, W., 8 p.m. 1. Mr. James Buchan, "The Volcanic Rocks of North-eastern Fife," with an Appendix by the President. 2. Mr. Frank Rutley, "Some Eruptive Rocks from the neighbourhood of St. Minver, Cornwall." 3. Mr. H. W. Monckton and Mr. R. S. Herries, "The Bagshot Beds of the London Basin." 4. Mr. Edwin Gilpin, jun., "The Geology of Cape-Breton Island, Nova Scotia."

Gas Institute, 25, Great George-street, S.W., 10.30 a.m. Reading of Paper and Discussion continued. 2 p.m. Visit to Colonial and Indian Exhibition.

Microscopical, King's College, W.C., 8 p.m. 1. Mr. F. R. Cheshire, "Device for the better examination of Bacteria in culture tubes. 2. Dr. E. M. Crookshank, "Photomicrography."

Royal Literary Fund, 10, John-street, Adelphi, W.C., 3 p.m.

Royal Society of Literature, 4, St. Martin's-place, W.C., 8 p.m.

THURSDAY, JUNE 10...Colonial and Indian Exhibition, South Kensington, S.W., 8½ p.m. Mr. F. W. Pennefather, "The Industries of New Zealand."

Royal, Burlington-house, W., 4½ p.m.

Antiquaries, Burlington-house, W., 8½ p.m.

Gas Institute, 25, Great George-street, S.W., 10½ a.m. Reading of papers and discussion continued.

Society for the Encouragement of Fine Arts, 8 p m. Conversazione at the Galleries of the Institute of Painters in Water Colours, Piccadilly, W.

Royal Institution, Albemarle-street, W., 3 p.m. Prof. A. Macalister, "Habit as a Factor in Human Morphology."

Mathematical, 22, Albermarle-street, W., 8 p.m.

FRIDAY, JUNE 11...Colonial and Indian Exhibition, South Kensington, S.W., 3 p m. Conference of the Royal Colonial Institute. Mr. F. Young, "Emigration to the Colonies."

United Service Institute, Whitehall-yard, S.W., 3 p.m. Colonel F. G. Ravenhill, "A Reserve of War Horses."

Royal Institution, Albemarle-street, W., 8 p.m. Weekly Meeting, 9 p.m. Professor Dewar, "Meteorite Problems."

Gas Institute, 25, Great George-street, S.W. Visit to Woburn Abbey.

Astronomical, Burlington-house, W., 8 p.m.

Quekett Microscopical Club, University College, W.C., 8 p.m.

New Shakspere, University College, W.C. 8 p.m. Paper by Mr. Frank Marshall.

SATURDAY, JUNE 12...Royal Institution, Albemarle-street, W., 3 p.m. Prof. G. G. Stokes, "Light, with special reference to Effects resulting from its Action on various Substances."

Physical Science Schools, South Kensington, S.W., 3 p.m. Mr. Walter Emmott and Mr. Wm. Ackroyd, "Electric Light Fire-damp Indicators."

Botanic, Inner Circle, Regent's-park, N.W., 3¾ p.m.

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FRIDAY, JUNE 11, 1886.

All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

NOTICES.

CONVERSAZIONE.

The Society of Arts Conversazione will be held, by permission of the Royal Commission, at the Colonial and Indian Exhibition, South Kensington, on Friday, the 16th of July next.

Each member will receive a card for himself, which will not be transferable, and a card for a lady. In addition to this, cards will be sold to members of the Society, or to persons introduced by a member, at the following prices:—Until the 3rd of July, 7s. each; after that date 10s. each, except on the 16th July, when the price will be 15s.

The Council, however, reserve the right of stopping the sale of tickets or of raising the price, if it is found necessary, in order to restrict the number of visitors within reasonable limits.

Tickets will only be supplied to persons presenting members' vouchers (forms of which can be obtained from the Secretary), or a letter of introduction from a member.

Members can purchase these additional tickets by personal application, or by letter addressed to the Secretary. In all cases of application by letter, a remittance must be enclosed. Each ticket will admit one person, either lady or gentleman.

Light refreshments (tea, coffee, ices, &c.) will be supplied at the usual buffets. No refreshments can be obtained by purchase. It will greatly facilitate the arrangements if members requiring additional tickets will apply for them at as early a date as convenient. The members' invitations will be issued in the course of next week. Visitors' tickets can be purchased from the present date.

There will be no admission to the Exhibition on this evening except by special ticket, and no tickets can be purchased at the Exhibition.

Further particulars as to the arrangements will be announced in future numbers of the *Journal.*

Proceedings of the Society.

CANTOR LECTURES.

PETROLEUM AND ITS PRODUCTS.

By Boverton Redwood, F.I.C., F.C.S.

[The right of reproducing these lectures is reserved.]

Lecture I.—Delivered March 8th, 1886.

In considering historically the subject of these lectures, it will be convenient to accept the name petroleum (which is obviously derived from the two Latin words *petra*, rock, and *oleum*, oil) in its broadest signification, as embracing not only the liquid oils which flow from the earth in various localities, but also the solid or semi-solid forms as well as the gaseous forms; and, in addition, the similar products obtained by the distillation of Boghead coal, bituminous shales, brown coal and peat.

Probably the earliest descriptive mention of petroleum was made by Herodotus who, about 450 B.C. gave an account of the pitch lakes of the Island of Zante, and referred to the use of bitumen which had been brought down by the waters of the Is into those of the Euphrates, in the building of the walls of Babylon. This writer describes a well at Arderrika, thirty-five miles from Susa, which produced asphalt, salt, and oil, the mixture being drawn from the well in half a wine skin, and poured into a receptacle, when the asphalt and salt became solid, and the oil, which was black and emitted a strong odour, separated.

A distinct reference to the use of petroleum occurs in the account of the building of the tower of Babel in the Book of Genesis, for the word "slime" in the English version is ἄσφαλτος in the Septuagint and *bitumen* in the Vulgate.

Sir Lyon Playfair is of opinion that some form of petroleum is more than once referred to in the Old Testament, under the generic name of salt, and he hazards the conjecture that Lot's wife was converted into a pillar of asphalt, as this would constitute an enduring monument which might have been seen by Josephus, and his contemporary, Clement of Rome, both of whom declared that they saw it, while a pillar of common salt would have been washed away by the first shower of rain.

Travellers to Persia and India, before the discovery of the Cape of Good Hope route, speak of the pitch fountain of Oyun Hit, on the Euphrates, and the people of the locality have a tradition that the bitumen for the building of the tower of Babel was collected there. The use by the Egyptians, for embalming, of the bitumen found in the valley of the Indus, is mentioned by Strabo and Diodorus of Sicily, and the former also relates how this substance rose to the surface of the Dead Sea during or after earthquakes.

The existence of the petroleum deposits of the Apsheron Peninsula has probably been known for at least 2,500 years, for it is believed that the Persian fire-worshippers frequented Surakhani from the time of Zoroaster, who lived not later than 600 B.C. The so-called "eternal fires" at Surakhani, result from the burning of the natural gas which issues from the ground in considerable quantity, and a temple still exists which, until recently, was frequented by fire-worshippers. When I visited this spot in 1884, the gas was not burning in the temple, but I had no difficulty in igniting it with a lighted match. A good illustration of this temple, from a drawing by Mr. William Simpson, appeared in the *Illustrated London News* for the 28th November 1885. It is worthy of note that a similar temple exists near Kangra, in the Punjab, where petroleum gas escapes from the ground, and it is probable that in past ages the same priests officiated in these localities, journeying with pilgrims from one to the other.

Aristotle, about B.C. 350, Strabo, B.C. 25, Pliny, about A.D. 50, Plutarch, about A.D. 66, and others, describe at some length deposits of bitumen occurring in Albania, on the eastern shores of the Adriatic Sea. Pliny and Dioscorides also mention the oil of Agrigentum, which was used in lamps under the name of Sicilian oil. Plutarch records that a Macedonian, who had charge of Alexander's baggage, is said to have dug on the banks of the Oxus, and that "there came out which differed nothing from natural oils, having the glosse and fatness so like as there could be discovered no difference between them."

Notices of petroleum springs and gas wells in China occur in the earliest records of that ancient people, the natural gas in that country having been used to evaporate brine for centuries before the Christian era.

The existence of petroleum oil and gas in Japan has also been known for a long period, and Mr. Lyman, in his first report on the Geological Survey of Japan, published in 1877, states that the oil wells of Echigo are supposed by the inhabitants to have been dug several hundred years ago. He adds:—

> "It is said in the Japanese history called 'Kokushiriyaku' (I am told) that rock oil (or 'burning water') was found in Echigo in the reign of Tenji-tenno, which was 1,260 years ago, or about A.D. 615, and that was probably at Kusôdzu, where there are still many natural exposures, as well as dug wells. The name of the place, Kusôdzu, is the name given in the country to rock oil, and it means 'stinking water;' and the very fact that the word is by contraction so much changed from its original form, Kusaimidzu, shows of itself considerable antiquity. Natural gas even is called Kazakusôdzu, the first two syllables meaning wind or air, and evidently identical etymologically with our very modern Western word, gas."

Gibbon states that, in A.D. 624, the Emperor Heraclius wintered at the mouth of the river Kura, seventy miles south of Baku, and that his "soldiers extinguished the fire, and destroyed the temples of the Magi." Marco Polo, who wrote in the 13th century, is supposed to have referred to the petroleum of Baku when he stated that there was in this neighbourhood an abundant spring of oil, not good for food, but good to burn or to anoint camels that had the mange; and he added that the people came from great distances to collect it. As far back as 1436, petroleum found on the shores of Lake Tegernsee, in Bavaria, was employed medicinally under the name of "St. Quirinus's oil." Francesco Ariosto states that he cured men and animals afflicted with itch with the petroleum which he had discovered in 1460 at Mont Libis, in the Duchy of Modena. Jonas Hanway, in the middle of the eighteenth century, described the so-called eternal fire at Surakhani as a flame in colour and gentleness not unlike a lamp that burns with spirit, only more pure, and sometimes rising to a height of eight feet when the wind blows. Hanway also described Tcheleken Island, which is on the opposite side of the Caspian Sea, as being peopled, in 1743, when he visited it, by thirty-six families who owned several wells of naphtha, and carried on a brisk trade in selling the oil to the Persians, Turkomans, &c., having no less than two dozen large boats employed in the transport of the liquid.

The earliest mention of the occurrence of petroleum in North America, which Mr. Peckham met with in compiling his elaborate and valuable report, presented to the United States Census-office in 1882, is dated 1629, though the existence and certain uses of petroleum were undoubtedly well known to the Indians very long before. In the year last mentioned, a Franciscan missionary, Joseph de la Roche d'Allion, who crossed the Niagara River into what is now the State of New York, wrote a letter (published in Sagard's "Histoire du Canada," 1632), in which he mentions the oil springs, and gives the Indian name of the place, which he explains to mean, "There is plenty there." In the year 1750, the commander of Fort Duquesne wrote to General Montcalm, describing the ceremonies of the Seneca Indians as ending in the ignition, by means of a torch, of the scum which covered the surface of a small stream which flowed into the Alleghany. About the same time, or a few years later, Peter Kalm published in Swedish a book of travels, in which was a map correctly showing the position of the springs in Oil Creek.

In 1765, the English Government sent an embassy to the Court of Ava, in Burmah, and in the journal of the Embassy Major Symes thus refers to the petroleum wells in the neighbourhood of the Yenangyoung (Earth-oil Creek) a small tributary of the Irrawaddy:—

> "After passing various lands and villages, we got to Yenangyoung, or Earth-oil Creek, about two hours past noon. We were informed that the celebrated wells of petroleum which supply the whole empire and many parts of India with that useful product, were five miles to the east of this place. The mouth of the creek was crowded with large boats waiting to receive a lading of oil, and pyramids of earthen jars were raised in and around the village, disposed in the same manner as shot and shell are piled in an arsenal. This is inhabited only by potters, who carry on an extensive manufactory, and find full employment. The smell of the oil is extremely offensive. We saw several thousand jars filled with it ranged along the bank; some of these were continually breaking, and the contents, mingling with the sand, formed a very filthy consistence."

In Galicia the existence of petroleum is said to have been discovered in 1771, in what is now the oil field of Sloboda-Rungurska, near Kolomea.

In 1788, a thick black variety of petroleum, occurring between Peklenicza and Moslowina, in Hungary, was examined by Winterl.

In 1791, Martinovich wrote an account of a dark brown variety of petroleum found in Galicia.

Dr. Gesner states that the existence of asphaltum and solid bitumen at Santa Barbara, in Southern California, has been known since 1792.

In 1811, the pitch lake of Trinidad, near the mouth of the Orinotas, was visited and described by Dr. Nicholas Nugent.

In 1817, Saussure examined the crude petroleum of Miano, in the Duchy of Parma, which was used at that time for lighting the streets of Genoa.

Mr. E. St. John Fairman states that Genoa was first lighted with Miano petroleum in 1802.

Mr. Charles A. Ashburner, geologist, in charge of the Pennsylvania Survey, is of opinion that possibly the first gas obtained commercially from a well in the United States was at Fredonia, Chatauqua County, New York, where a well was sunk on the bank of Canadaway Creek, near the main street bridge, in 1821, and sufficient gas obtained for thirty burners, the inn having been illuminated by the gas when General Lafayette passed through the village about 1824.

I have already stated that the discovery of the existence of petroleum in Galicia was made in 1771. The oil was, however, used simply as a cart grease, but, according to Dr. Gintl, in 1817 the distillation of Galician petroleum was commenced, and the Alstettering, in Prague, was lighted with the product. The refinery which supplied the total requirements of the city in question (300 cwts. per annum) was situated at Kabicza. The oil appears to have been sold at 55 florins per cwt. The company which carried on this refinery suspended operations in the following year.

Persian petroleum was distilled by Unverdorben in 1829, and a small quantity of a solid "fat" obtained; and in 1831, Christison and Gregory obtained paraffin from Rangoon petroleum.

In 1830, Reichenbach separated paraffin from wood tar, and Laurent obtained it by distilling bituminous shale.

In 1836, the petroleum from the Tegern Lake in Bavaria, already referred to as being known under the name of St. Quirinus oil, was examined by Kobell.

In 1833, Professor Silliman published the following account of the oil well of the Seneca Indians, near Cuba, New York:—

> "The oil-spring, or fountain, rises in the midst of a marshy ground; it is a muddy and dirty pool of about 18 feet in diameter. The water is covered with a thin layer of petroleum, giving it a foul appearance, as if coated with dirty molasses, having a yellowish-brown colour. They collect the petroleum by skimming it, like cream from a milk-pan. For this purpose they use a broad flat board, made thin at one edge, like a knife; it is moved flat upon, and just under the surface of the water, and is soon covered by a thin coating of the petroleum, which is so thick and adhesive that it does not fall off, but is removed by scraping the instrument upon the lip of a cup. It has then a very foul appearance, like very dirty tar or molasses, but it is purified by heating or straining it while hot through flannel or other woollen stuff. It is used by the people of the vicinity for sprains and rheumatism, and for sores on their horses, it being in both cases rubbed upon the part."

In 1836, Dr. Hildreth described the petroleum deposits in little Kanawha.

Between that date and 1847, when Mr. James Young obtained the right of working a petroleum spring in the Riddings colliery, at Alfreton, in Derbyshire, to which his attention had been directed by Sir Lyon Playfair, many descriptions of petroleum deposits in different parts of the world were contributed by travellers; and several chemists published results obtained in the analyses of petroleum from various localities, and in the destructive distillation of bodies capable of yielding similar products. In 1850, Mr. Young produced paraffin oil by the distillation of Boghead or Torbanehill mineral, and in that year obtained a patent for his process. Laurent had, however, in 1833, suggested the working of the bituminous shale found at Autun as a source of mineral oil; and, in 1839, burning oil and other products manufactured from this material were exhibited by Selligue. The first successful attempt to manufacture burning oil from coal in America is stated to have been made by Dr. Abraham Gesner, who burned in lamps an oil thus made at public lectures at Prince Edward's Island, in August, 1846; Dr. Gesner subsequently sold the patents granted to him to the North American Kerosene Gas-Light Company, who manufactured the oil at their works at Newtown Creek, Long Island, and sold it, in 1854, under the name of kerosene oil. Dr. Gesner states that Messrs. Austen, the agents of the company, "found great difficulty in selling the oil. The refining process was not so well understood at that time as at present, and the odour was not agreeable The beauty of the light obtained from it, however, was sufficient to gradually overcome the objection to it on the score of odour. Its supposed explosiveness was also urged against it by those interested in the camphine and burning fluids."

In 1849, commercial attempts were made to obtain mineral oil from peat in Ireland, and in 1850 the distillation of lignite for paraffin oil was commenced on the Rhine.

In 1852, Mr. Young obtained an American patent for his process of producing burning oils and paraffin from bituminous coals.

Referring to the lighting of Prague with Galician petroleum in 1817-18, and pursuing the development of the industry in general in chronological order, we again come to Galicia. It would appear that between 1818 and 1852 no further attempts were made to produce a lighting fluid from petroleum in that country. In the latter year, however, according to Dr. Gintl, a person named Schreiner, carrying on the business of manufacturing cart grease from crude petroleum, collected one day, when boiling the material, the drops of liquid which condensed on the cover of the vessel, and took some of the strong smelling oil to an apothecary named Mikolasch, who had an assistant named Lukasiewicz. The latter, with his colleague, Zeh, treated the liquid with sulphuric acid, and subsequently with caustic soda, and found that the refined oil burned well.

About the same time, or possibly in the previous year (1851), mineral burning oil of a reddish brown colour, made in Scotland, is said to have been sold in Vienna at 43 florins per cwt.

In 1853, Galiciar petroleum was substituted for candles in the lighting of the station of the Emperor Ferdinand's North Railroad, and in the following year this oil became an article of commerce in Vienna.

In 1853, the United States Chemical Manufacturing Company commenced to make a lubricating oil from coal-tar at Waltham, Massachusetts; and, in 1857, the Downer Kerosene Oil Company first made mineral oils for lubricating purposes from Albert coal obtained from New Brunswick. Meanwhile, at New Bedford, Massachusetts, the distillation of Boghead mineral imported from Scotland was commenced, but cannel coals from West Virginia and Kentucky were soon substituted for the imported material; and so rapidly did the industry develop that, in 1859, a single refinery on the Alleghany River had a distilling capacity equal to 6,000 gallons of crude oil per diem.

Commenting on the situation at this period, Mr. Peckham remarks that it was alone owing to the scarcity of supply that crude petroleum was not employed as the source of burning oil prior to 1859, and he adds that in fact the American refiners used bituminous coal just as Mr. Young was driven to employ a similar material when the scanty supply of oil from the Alfreton coal mine was found inadequate. In America, however, the production of crude petroleum, which increased with giant strides, as we shall presently see, after the year 1859, rendered the situation totally different from that which it remained in Scotland, and in America the distillation of coal ceased from that date to be profitable.

The drilling of the celebrated Drake well in the United States, in the year 1859, marks the commencement of the rapid growth of the petroleum industry in that country, but the credit of the adoption of that method of obtaining the crude oil does not belong solely to Colonel Drake. As long previously as 1806, the brothers Ruffner commenced drilling for brine, and in the course of succeeding years laboriously perfected a system of drilling which is substantially that which is adopted at the present time in sinking petroleum wells. Moreover, the wells which were thus drilled for brine yielded petroleum sometimes in considerable quantities. Thus, in 1829, a well was drilled near Burkesville, Kentucky, for the purpose of obtaining brine, and a vein of oil was struck which at intervals of five minutes emitted many barrels of oil. It is stated that this well continued flowing until the year 1860, yielding a plentiful supply of oil, which for some time was put up in bottles, and sold as American medicinal oil.

In 1854, Mr. Warren de la Rue obtained a patent for the manufacture of paraffin and other products from petroleum. The crude oil he used was imported from Rangoon, and Price's Patent Candle Company, and Messrs. Charles Price and Co., continued to work this material until the development of the American petroleum industry rendered their operations no longer profitable.

The development of the oil territory of Canada dates from 1857, when a well dug for water was found to yield a large quantity of petroleum; but Henry states that, from the time of the earliest settlements in the county of Lamberton, in the western part of the province of Ontario—

> "A dark oily substance had been observed floating on the surface of the water in the creeks and swamps. No matter how deep the wells were dug, the water was brackish and ill-smelling, and in some localities totally unfit for use; while a surface of black oily slime frequently arose, an inch thick, as cream rises on milk. Here and there in the forest the ground consisted of a gummy odoriferous tar-coloured mud, of the consistence of putty. These places were known by the name of gum-beds, and in two or three instances were of considerable extent."

Referring again to Galicia, we find that the brine well which, in 1771, had led to the existence of petroleum in the Sloboda-Rungurska district being observed, in consequence of a small quantity of petroleum being brought to the surface with the brine, was deepened, in 1859, to twenty-five metres, and produced continuously a certain quantity of petroleum. I may remark here that, according to Dr. Gintl, this historic well was further deepened in 1879, and then produced from 10 to 20 cwt. of crude oil per day.

Prior to the drilling of the Drake well, the attention of those who were making oil from cannel coal in the United States was directed to various kinds of crude petroleum, and the possibility of obtaining this product in larger quantity than it had hitherto been collected, received consideration. In 1854, a tract of land 105 acres in extent, on what was known as Watson's Flats, embracing the island at junction of Pine and Oil Creeks, was secured for the purpose of experimental drilling. This property was ultimately leased to an organisation termed the Seneca Oil Company, who employed Mr. Drake to drill an artesian well for oil. Mr. Drake "struck oil" on the 28th August, 1859, when the drill entered a cavity in the rock at a depth of thirty-three feet, and fell six inches. On the following day (Sunday) Mr. William Smith, who with his two sons had been employed in the work of drilling, found the bore hole nearly full of a liquid, and on drawing up a small quantity of this in a tin cup he found it to be petroleum.

After this successful result, drilling for oil took place with great activity, but was confined chiefly to the villages of the Alleghany river and its tributaries, and the various coal-oil refineries throughout the country began to distil the crude petroleum in place of coal. In 1865, the area of producing territory was immensely enlarged, wells being bored over a tract of country extending from Manitoulin island to Alabama, and from Missouri to central New York. Permanent oil territories were thus developed in southern Kentucky, in West Virginia, in Washington County, Ohio, and in Trumbull County, Ohio, at Mecca. In Pennsylvania, oil was also found at Smith's Ferry, on the Ohio river, in Beaver county, and the hill region lying in the angle formed by Oil Creek and the Alleghany river, from Tidioute across to Titusville. Henry states that:—

> "At the end of 1861 commenced the flowing-well period, with an addition to the production of 6,000 or 7,000 barrels a day. The price fell to 20 cents a barrel, then to 15 cents. and then to 10 cents. Soon it was impossible to obtain barrels on any terms, for all the coopers in the surrounding country could not make them as fast as the Empire well could fill them. Small producing wells were forced to cease operations, and scores of operators became disheartened, and abandoned their wells. The production during the early part of 1863 was scarcely half that of the beginning of 1862, and that of 1864 was still less. In May, 1865, the production had declined to less than 4,000 barrels per day. Commencing at Titusville, in 1859, the tide of development swept over the valley of Oil Creek, and along the Alleghany river above and below Oil City for a considerable distance; then Cherry run in 1864. Then came Pithole Creek, Benninghoff, and Pioneer Run; the Woods and Stevenson farms, on Oil Creek, in like succession, in 1865 and 1866; Tidioute and Triumph hill in 1867, and in the latter part of the same year came Shamburg. In 1868, the Pleasantville oil field furnished the principal centre of excitement."

For nearly a century bitumen had been known to exist in Southern California, between Santa Barbara and Los Angeles, and had also been observed floating upon the sea in Santa Barbara Channel, between the islands and the mainland. In 1864, the drilling of wells and the driving of tunnels into the mountain side upon the petroleum bearing rock commenced in this locality, but the operations were attended with but little success, the annual production never exceeding a few thousand barrels of inferior oil. More recently there have been promising developments of oil-bearing territory in a portion of the State further north.

From 1870 to 1880 the region between Tidioute and Oil Creek gradually became of smaller importance in relation to the entire producing territory in Pennsylvania. Wells had previously been drilled near the junction of the Clarion and Alleghany Rivers, and in 1868 a successful well on the hill above Parker's landing led to the development of what is termed "the lower country," lying in Butler, Armstrong, and Clarion counties.

In the meantime other operators prospecting in a north-east direction from the "upper country" of Oil Creek, found oil in the neighbourhood of Bradford, in McKean County, and thus commenced the development of the enormously productive Bradford territory. In December, 1878, four years after the drilling of the first successful well in the Bradford district, the production of oil in that locality amounted to a daily average of 23,700 barrels, or about four-sevenths of the total daily production of the State of Pennsylvania, and two years later the Bradford field produced 63,000 barrels out of a total of 72,215 barrels.

In a paper read at a meeting of the American Institute of Mining Engineers, in September, 1885, Mr. Ashburner, geologist in charge of the Pennsylvania Survey, classified the present producing territory in Pennsylvania and New York States into the following six principal districts:—

1. Alleghany district, including Richburg, with an area of twenty-eight square miles, and several small outlying pools in Alleghany County, bringing up the total area to thirty-one square miles.

2. Bradford district, embracing the oil pools in central and northern McKean County, Pa., and Southern Cattaraugus County, New York, with an area of 133 square miles, 121 square miles of which is included in the Bradford field proper.

3. Warren district, comprising the oil pools in eastern Warren County, and north-eastern Forest County, Pa, with a total area of 35 square miles, the two largest pools being the Clarendon in Warren County, with an area of fourteen square miles, and the Cooper and Sheffield, partly in Warren and partly in Forest, covering an area of nine square miles.

4. Venango district, with an area of sixty-five square miles, including forty distinct and well-recognised pools, the largest being that which lies between Oil City on the south and Pleasantville on the north, covering an area of twenty-eight square miles.

5. Butler district, including the oil pools in Butler and Clarion Counties, and south-eastern Venango County, the total area being eighty-four square miles, of which seventy-six are embraced in the Clarion, Butler, and Armstrong fields, and the Butler Cross-belt.

6. Beaver district, including the two principal oil pools known as Slippery Rock and Smith's Ferry. The former pool and that portion of

the latter east of the Pennsylvania State line cover an area of about sixteen square miles.

Outside of the limits of these districts a small amount of oil has been found in isolated pools at the south and south-east of the Beaver and Butler districts; at Mount Nebo, in the vicinity of Pittsburg; in the neighbourhood of Pleasant Unity, Westmoreland County; near the mouth of Dunlap Creek, in Fayette Country; along Whiteley Creek, west of Mapletown, and along Dunkard Creek, north of Fairview, both in Green County; and in the vicinity of Washington, Washington County.

In a report dated last January, Mr. John C. Welch, of New York, petroleum statistician, remarks of the two newest oil-fields in the United States, the Kane and the Washington, that their discovery introduces possibilities of future developments of which no valuable estimate can be made. He adds—

> "The general trend of development, extending from Alleghany and Bradford, south-west through the middle field, takes in Venango territory; immediately south of Venango is the Clarion and Butler development, with a trend to the south-west. Kane lies just outside of the Alleghany-Venango belt, south and east of it, and about forty miles from the Clarion territory. It would be forcing things to say that the intervening territory between Kane and Clarion would be filled in with pools and belts, like the Alleghany-Venango belt, but it must be admitted that the Kane development greatly helps the outlook for producing in Elk country, which can be classed as virgin territory regarding oil, although some condemnatory test-wells have been drilled in different parts of it. Washington country is almost *terra incognita* regarding oil. By referring to a map of Pennsylvania, it can be seen that it is a big jump from Butler County to Washington County; yet a first-class field is now opening up at the latter place, and a strong presumption is established that there will be a good deal of filling in of producing territory in the intervening 50 miles."

Mr. Welch remarks that, in view of these facts, the declining production of the Bradford field loses its significance.

There are at present about 20,000 more or less productive wells in the oil-fields of the United States.

The following tabular statement shows the growth of the production of crude petroleum in the United States from 1859 to the present time. It is based partly on the information furnished by Stowell's "Petroleum Reporter," and partly on figures obtained from other reliable sources. There are probably no statistics even approximately accurate of the production in 1859 available. By some authorities the amount is given as 2,000 barrels, but I am informed that it no doubt was far nearer 5,000 barrels:—

PRODUCTION OF CRUDE PETROLEUM IN THE UNITED STATES.

Yrs.	Barrels.	Yrs.	Barrels.
1859	5,000	1873	7,878,629
1860	500,000	1874	10,950,730
1861	2,113,000	1875	8,787,506
1862	3,056,000	1876	9,175,906
1863	2,611,000	1877	13,490,171
1864	2,116,000	1878	15,165,462
1865	2,497,000	1879	19,741,661
1866	3,597,000	1880	26,562,000
1867	3,347,000	1881	28,447,115
1868	3,583,176	1882	31,051,165
1869	4,210,720	1883	24,090,000
1870	5,673,195	1884	23,520,817
1871	5,715,900	1885	21,600,651
1872	6,531,675		

The production of crude petroleum in the United States, during the year 1885, was, as we have seen, 21,600,651 barrels,* while the total consumption amounted to 23,258,750 barrels. A portion of the supply was therefore derived from the accumulated stocks, but at the end of the year these stocks amounted to 35,368,554 barrels. Mr. Welch estimated that it cost about £1,000,000 sterling per annum to hold this quantity of crude petroleum in the United States.

An account of the progress of the petroleum industry in the United States would not be complete without a reference to the rapid development of the use of natural gas for lighting and heating. The most important gas field is that which is situated about fifteen miles from Pittsburg, and was thus described by Mr. Andrew Carnegie in January, 1885:—

> "The centre of this natural gas district is the village of Murraysville, in Westmoreland county. In the race of a small flour mill at that place a larger amount of gas than usual had been noticed, and fifteen years ago a party of speculators bored there, hoping to find oil; but after boring to a depth of 900 feet, nothing was found. Several years later another party concluded to try it again, and decided not to stop boring until a much greater depth had been reached. Their hope, of course, was that oil could be obtained, but when they had bored to a depth of 1,320 feet a tremendons explosion occurred, which drove the drills from the well into the air, and

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* This amount does not include the "runs" of some of the smaller pipe lines and heavy oil.

broke everything to pieces. The roar of the escaping gas was heard in Monroeville, five miles away....... After four pipes, each two inches in diameter, had been laid from the mouth of the well, and the flow directed through them, the gas was ignited, and the whole district lighted up for miles around. This valuable fuel was permitted to waste for five years, as capitalists could not be found who were willing to risk the £40,000 for pipes to convey it to the factories and mills where it could be utilised.

"I visited this region last week, and saw nine wells furnishing gas. The gas from the three largest was still passing into the air. These are wonderful sights indeed. The gas rushes up with such velocity through a 6-inch pipe, which extends perhaps 20 feet above the surface, that it does not ignite within 6 feet of the mouth of the pipe. Looking up into the clear blue sky, you see before you a dancing golden fiend, without visible connection with the earth, swayed by the wind into fantastic shapes, and whirling in every direction. As the gas from the well strikes the centre of the flame and passes partly through it, the lower part of the mass curls inward, giving rise to the most beautiful effects, gathered into graceful folds at the bottom, a veritable pillar of fire. There is not a particle of smoke from it."

The second district described is that of which the town of Tarentum on the Alleghany River, twenty miles from Pittsburg, forms the centre, and the third district is that of which Washington, Pa., about twenty-five miles south of Pittsburg is the centre. A pipe line has already been laid from this third district to iron mills along the banks of the Ohio at Pittsburg.

Detailed information in regard to the production of petroleum oil and gas in the United States will be found in the *Petroleum Age*, published in Bradford, Pa.

Having thus sketched the general history of the petroleum industry, and traced its development in the United States to the present time, I must ask you now to consider with me what has been done to utilise the crude oil and oil-producing minerals in other countries, before I proceed to indicate the geographical distribution of the material by describing deposits which have not yet been commercially utilised.

The Russian petroleum industry, as that which ranks second in importance, must first receive our attention.

The town of Baku, where the industry we are considering is located, lies upon the southern shore of the bay formed by the peninsula of Apsheron, which projects from the mainland of Trans-Caucasia. The northern side of the peninsula is tolerably fertile, but the neighbourhood of Baku presents the appearance of a sandy desert.

The principal producing wells are situated in what is termed the Balakhani or Balakhani-Saboontchi district, about eight miles from the town of Baku, and at an elevation of rather less than 200 feet above sea-level. Other wells of minor importance are situated a few miles distant, at Surakhani, on the site of the fire temple referred to.

Upon the annexation of Baku by Russia, in 1801, the monopoly of the production of petroleum was granted to a refiner named Meerzoeff. This arrangement continued until 1872, when an excise duty upon all petroleum raised was imposed. The duty was abolished in 1877. Mr. Marvin states that, from 1821 to 1825, Meerzoeff paid the Government 131,000 roubles revenue, and afterwards, up to 1839, from 76,000 to 97,000 roubles a year, or, at the high rate of the silver rouble then prevailing (ranging between six and seven roubles to the pound sterling), on an average about £10,000 to £12.000 sterling. During this period the production of crude petroleum rose steadily to more than a million gallons. Afterwards the output was as under:—

	Tons.	Revenue in Roubles.
1840	3,565	105,000
1841	3,421	117,000
1842	3,470	124,000
1843	3,434	119,000
1844	3,443	125,000
1845	3,432	100,000
1846	3,480	93,000
1847	3,490	94,000
1848	4,351	108,000
1849	3,340	100,178

In 1849, there were about 130 pit wells in operation. Between 1850 and 1863 petroleum yielded a total revenue of 1,195,000 roubles. From then to 1867 the average revenue yearly was 162,000 roubles, and afterwards, until the abolition of the monopoly, and substitution of an excise duty, in 1872, 136,000 roubles. The production, in the meantime, was as under:—

Yrs.	Tons.	Yrs.	Tons.
1863	5,484	1868	11,900
1864	8,700	1869	27,180
1865	8,900	1870	27,500
1866	11,100	1871	22,200
1867	16,100	1872	24,800

In 1872, the number of pit wells had increased to 415, and two wells had been drilled.

After the abolition of the monopoly, Meerzoeff for a time maintained his supremacy in the trade, but, in 1873, the Khalify Company struck a flowing well, and thus obtained the largest supply of the crude material, and a year later, the Transcaspian Trading Company—afterwards called the Baku Petroleum Company—took the lead in the business. In 1875, Messrs. Robert and Ludwig Nobel inaugurated a new era in the Russian petroleum industry, introducing improved appliances for producing, transporting, and refining the oil, and gradually building up the great organisation which, under the name of the Nobel Company, now conducts so large a proportion of the Russian petroleum business.

During the excise duty period, the production and price of crude petroleum were as under:—

		Price per ton.	
	Tons.	s.	d.
1873	64,000	7	9
1874	78,000	6	3
1875	94,000	15	6
1876	194,000	7	9
1877	242,000	12	6

In 1877, the number of drilled wells had increased to 130.

From 1877 to the present time the production and price of the crude oil have been as follows:—

		Price per ton.	
	Tons.	s.	d.
1878	320,000	8	8
1879	370,000	6	3
1880	420,000	3	8
1881	490,000	2	6
1882	680,000		
1883	800,000		
1884	1,130,000		
1885	1,370,967		

When I visited Baku in the autumn of 1884, there were about 400 drilled wells in the neighbourhood, but I was informed that only about 100 of these were, at the time of my visit, producing. Of the 100 wells only some 20 were flowing wells. The producing territory on which all the wells supplying the requirements of the Baku refiners are situated is not more than three and a half miles square. Some of the wells are, however, enormously productive. I saw one throwing up a stream of oil at the rate of more than one million gallons per twenty-four hours, and others have yielded at the rate of more than double that quantity.* We shall presently see that this small tract of land bears a very small proportion to the total area of the petroleum lands of Southern Russia, and when we come to consider the geographical aspect of our subject, we shall have to deal with other regions in this country, in which more or less oil has been obtained.

I have already referred to the development of the oil territory in Canada, and it remains but to add that the district where the oil has been found is, according to Mr. Peckham, in size about fifty miles north and south, by one hundred miles east or west. Nearly all the oil has, however, been found at Petrolia, sixteen miles south-east of the outlet of Lake Huron; at Oil Springs, seven miles south of Petrolia; and at Bothwell, about thirty-five miles from Oil Springs. More than nine-tenths of the total quantity of crude oil produced in Canada comes from Petrolia, but the most productive wells have been situated at Oil Springs. When I visited Ontario, in 1877, I found the refining of petroleum being carried on extensively at London. Three years ago, the yield of crude oil in Canada from the 1,600 wells then actively producing was stated to be only 2,400 barrels per diem.

The Galician petroleum-producing districts are four in number, and their locality and yield in 1883 were thus stated by Dr. Gintl:—

	Crude oil per annum. metre-centners.
In West Galicia—	
1. Sandez and Gorlice	91,500
2. Jaslo and Sanok	44,900
In East Galicia—	
3. Sambor and Drohobycz	73,600
4. Kolomea	300,000

The third district produced in addition 105,200 cwts. of ozokerit. There were then 3,500 producing wells.

The Sloboda-Runsgurska section of the Kolomea district is by far the most productive. Its development was not commenced until 1881, and at the end of 1883 it was reported to be yielding 550 barrels of crude oil per day, within an area 1,500 metres in length and 350 to 500 metres in breadth. In 1883 there were reported to be 57 refineries in operation, producing 186,500 cwts. of burning oil per annum.

The United States Consul-General in

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* The Armstrong No. 2 well, in Butler County, Pennsylvania, one of the most prolific known in the United States, yielded only 260,000 gallons per twenty-four hours.

Vienna, writing in 1880, states that in 1879, Mr. James Carrigan, who had been an oil refiner in Cleveland, Ohio, commenced the erection of the first steam refinery in Galicia, and in the following year completed the construction of plant capable of producing daily 150 barrels of refined oil.

The chief sources of the refined petroleum which the world is consuming have now been referred to, and before proceeding to describe sources of crude petroleum that have not yet become commercially important, we have to consider the history of the shale oil industry. We have already seen that this industry had its origin in some experiments which Mr. James Young was led to make, at the suggestion of Sir Lyon Playfair, in the distillation of petroleum which was found oozing through the top of a coal-working at the Riddings Colliery at Alfreton, in Derbyshire. Through the kindness of Mr. C. Tylden Wright, F.G.S., of the Shire Oaks Colliery, near Worksop, to whom Mr. John Calderwood was some time ago good enough to introduce me, I am able to place before you a specimen of a similar petroleum, and of the rock out of which it is now flowing intermittently at the Southgate colliery, Clowne, near Chesterfield, at the rate of from 70 to 100 gallons per day, in admixture with an equal quantity of water. The section on the table indicates the geological position of the rock at a depth of 320 yards. The dip of the strata is about 1 in 12 east, and the ground much broken up by faults. Mr. Tylden Wright informs me that Mr. Oakes, the owner of the Riddings Colliery, has seen the spring from which the sample before you was taken, and is of opinion that the flow, though intermittent, is greater than that which originally attracted Sir Lyon Playfair's attention.

After two years' successful working, the petroleum spring utilised by Mr. Young ceased to flow, and in 1850 Mr. Young, in conjunction with Mr. E. W. Binney and Mr. Meldrum, commenced the production of paraffin oil by the distillation of Boghead or Torbanehill Mineral. This mineral yielded 120 to 130 gallons of crude oil per ton.

The use of this mineral led to a notable law suit, which turned upon the question whether the material was a "coal," the ultimate decision being in the affirmative. In 1862, however, the supply became exhausted, and since that date paraffin oil has been exclusively produced from bituminous shales.

(To be continued.)

Miscellaneous.

COLONIAL AND INDIAN EXHIBITION.

CONFERENCES.

On Friday last, June 4th, a Conference of the Royal Colonial Institute was held, when a paper was read by Mr. J. D. Wood, on "The System of Land Transfer adopted by the Colonies."

On Saturday the first of the Conferences convened by the Geologists' Association, on "The Mineral Resources of the Colonies and India," was held, when a paper was read by Professor V. Ball, F.R.S., on the "Mineral Resources of India and Burmah." The discussion turned on the urgent need for reform of the mining laws of India, and the following resolution, proposed by the Chairman (Sir R. Temple), and seconded by the Duke of Manchester, was unanimously adopted:—"This Conference having had under its review the mineral resources of India and the obstacles to development and exploitation of the same, through the want of suitable or sufficient mining laws, respectfully urges upon the Secretary of State for India the desirability of regulating or revising the regulation for the working of mines in British India, including Burmah, and for the protection of mining interests therein, and also of negotiating arrangements to the same effect with the Native States." The next Conference of the Geologists' Association will be held on Saturday, June 19th, when Professor T. Rupert Jones, F.R.S., will read a paper on the "Mineral Resources of South Africa," and Sir Charles Mills will preside.

On Monday, June 7th, the subject of the Conference of the Anthropological Institute was the "Native Races in British Possessions in America and the West Indies." On Tuesday afternoon was held the Conference of the National Association for Promoting State-directed Colonisation, and in the evening of the same day Mr. Alexander Begg lectured on "The Canadian North-West." On Wednesday afternoon, Mr. L. J. Shand read a paper on "British Grown Teas," and on Thursday evening, Mr. F. W. Pennefather lectured on the "Industries of New Zealand."

RECEPTION COMMITTEE.

The tours and entertainments arranged by the Reception Committee commenced on the 27th of May, with a trip down the river, given by the British Indian Steam Navigation Company, and the arrangements have been fixed up to July 3rd. On Wednesday, June 2nd, the Peninsular and Oriental Steam Navigation Company gave a river trip. On Friday last H.R.H. the Princess Louise (Marchioness of Lorne) gave a garden party at Kensington Palace, and on Saturday there was an excursion to Sir Thomas Brassey's, at Normanhurst, and to Battle Abbey.

On Monday, 7th inst., the Marchioness of Salisbury gave a garden party at Hatfield. On Tuesday the Orient Steam Ship Company gave a river trip, and on Wednesday there was an excursion to Lord Vernon's, at Sudbury, for the Conference of the British Dairy Farmer's Association, but this last was limited to six *bonâ fide* agriculturists. On Thursday, the 10th, there was an excursion to the India-rubber, Gutta-percha, and Telegraph Works, at Silvertown.

On June 14, the British India Steam Navigation Company will give another river trip, and two days later the Earl of Carnarvon will receive a party at Highclere Castle. On June 22, Mr. Walter will entertain a party of 100 colonials at Bearwood. The agriculturists will have another day, on June 23, when the Duke of Bedford will receive them at the Woburn Experimental Farm, and entertain them to lunch at Woburn Abbey. On the 24th, the Crystal Palace Company will give the colonists a day; while the day following will be devoted to an excursion to Windsor and Eton. But the great excursion in the present series will extend from June 28 to July 1. It includes Oxford, Leamington, Birmingham, Warwick Castle, Guy's Cliff, Kenilworth, Stoneleigh Abbey, Stratford-on-Avon, Clopton-house, and Charlecote-park. At Oxford, the Mayor will provide lunch; the Mayor of Leamington will give a banquet and *conversazione*; while the excursionists will be again lunched by Lord Leigh and the Mayor of Stratford-on-Avon, the Mayor of Stratford, Mr. Arthur Hodgson, C.M.G., himself an old colonial, and the general secretary of the Reception Committee. Last of the present series there will be, on July 2, an excursion to Aldershot to witness the parade of troops in presence of Field-Marshal his Royal Highness the Prince of Wales, and Field-Marshal his Royal Highness the Duke of Cambridge.

The Times concludes an article on this subject with these words:—"Such are the entertainments which have been specially arranged for by the Reception Committee. The Committee deserve every credit for the exertions they have made to convince our Colonial and Indian brothers that we are heartily glad to have them among us. But all this cannot be done without considerable expenditure. Indeed, as we stated in a previous article, it is estimated that it will take £5,000 to cover all expenses connected with the work of the Committee. Of course, it is not to be expected that the members of the Committee are to pay this out of their own pockets, nor are the funds of the Exhibition available for any such purpose. It is, therefore, clear that the Committee cannot continue to carry on their work efficiently without subscriptions from the public. There are always a large number of generous and wealthy persons willing to give to any laudable object when brought before them; there could, at present, we are sure, be no more worthy object than convincing our fellow-citizens from the Colonies and India how welcome they are. There has been a good deal of talk of this kind in connection with the Exhibition; let us show that we mean it by putting our hands in our pockets. The treasurer is Mr. H. Trueman Wood, Society of Arts, John-street, Adelphi. At the close of the Exhibition an account of the expenditure, with a list of the subscribers and the amount of their subscriptions, will be published. We are sure there are many individuals and corporations that would not like to have their names conspicuously absent from such a list."

Correspondence.

THE DUTY ON SILVER AND GOLD PLATE.

With reference to the discussion on Mr. B. H. Baden Powell's paper on "Indian Manufactures, from a Practical Point of View" (see *ante* p. 708), Mr. Martin Wood writes:—We have no control over the trade of France or America, but we have absolute power over that of India. We have forced our exports on that country, and both our political parties joined, at the bidding of Lancashire, to compel our piece goods to be admitted into India duty free. In striking contrast with this deference to a clamorous trade interest here, we continue to tax the special industry of the Indian workmen in gold and silver plate at a rate that amounts to 30 or 40 per cent. of the sale price, with the effect of excluding his wares from our home market. No one, except the "fair traders," wishes to maintain in favour of the Indian artisan a differential duty against other silver plate; but the whole receipt from this barbaric and antiquated impost should be considered as a trifle compared with the relief that its abolition would afford to one of the most suitable and meritorious of the ancient handicrafts of India. That country has protested and petitioned in every form against the maintenance of what is felt as a peculiarly invidious embargo on this branch of Indian industry which, except by special dispensation, is almost shut out of the present imperial show. No time could be so fitting as the present for abolishing the vexatious exclusion. The Society of Arts has often interceded, by its Council, on behalf of struggling or unfairly overweighted industries, and one could not easily conceive a case more suitable for its intervention than this of the almost ruined silver and gold plate art of India.

Permit me, as I am writing, to refer to another subject spoken of by Mr. Baden Powell (p. 708), that of the obstacle to paper-making in India caused by the undue expensiveness of bleaching agents when imported, and the absence of local production of those agents. He confessed that he did not know why "the local production of the requisite chemicals has not yet been successfully undertaken." This anomaly was partly explained in the appropriate general remark (p. 720) by the Chairman, Sir Juland Danvers:—"In India, industry and skill were present, but something was wanting to develop them, and that was capital." Just so; and this specially applies to this essential of manufacturing chemicals. The materials are available, cheap, and abundant in many parts of India; and, since the medical and other colleges have popularised a knowledge of practical chemistry, there are, in all the large cities, scores of young men who, under proper guidance, could apply that knowledge, and thus save millions to Indian production; but they have not the capital to set up the requisite plant. Some European firms in India might supply this essential factor, and thus give a great impetus to indigenous manufactures in many directions.

General Notes.

Karlsruhe Small Industries Exhibition.—Under the patronage of the Grand Duke of Baden, and with the concurrence of the Grand-Ducal Government, the Industrial Society of Karlsruhe has organised an international exhibition of the manual arts and domestic economy, to remain open from 15th August to 15th September, 1886. The principal object of the Exhibition is to make known the best *matériel* and apparatus suitable for small industries, and to popularise their use, so that small motors, tools, and machine tools, whether made in the country or abroad, and whether shown by manufacturers or dealers, will be welcomed.

Exhibition at Conegliano.—An important exhibition of apparatus and implements for the prevention of the diseases of the vine, and for destroying insects that infest it, was held last month at Conegliano. The exhibitors, who were not limited to Italians, were 197 in number, and of the 524 different machines, apparatus, and implements shown, 450 were connected with application of milk of lime, the most effectual remedy for the disease called *peronospora*, the proportion being from 8 to 10 of shaked lime to 100 of water. The experiments, made before a jury composed of the most eminent viticulturists and scientific men, which lasted five days, will be described in a report to the Minister of Agriculture, and will contain a variety of useful information and plates. Three gold medals, three silver with money prize of 150 francs, seven silver ones, and four bronze ones were awarded, and besides these, three special premiums were given by the local agricultural committee.

MEETINGS FOR THE ENSUING WEEK.

Tuesday, June 15...Colonial Institute, St. James's Banqueting-hall, 69, Regent-street, W., 8 p.m. Sir George F. Bowen, "The Federation of the British Empire."

Wednesday, June 16...Meteorological, 25, Great George-street, S.W., 7 p.m. 1. Mr. Robert H. Scott, "Note on a Sudden Squall, January 13th, 1886." 2. Mr. F. Gaster and Mr. W. Marriott, "The Floods of May, 1886." 3. Captain W. Nelson Greenwood, "Atmospheric Pressure and its Effect on the Tidal Wave." 4. Mr. J. D. W. Vaughan, 'Meteorological Results at Levuka and Suva 1875-1885, with Notes on the Climate of Fiji."

United Service Institute, Whitehall-yard, S.W., 8½ p.m. Colonel H. T. Arbuthnot, "The new military Rifle, and its comparison with other military Rifles, English and Foreign."

Thursday, June 17...Colonial and Indian Exhibition, South Kensington, S.W., 4 p.m. Mr. A. Wilmot, "The Commercial Condition of Cape Colony."

Linnean, Burlington-house, W., 8 p.m. 1. Mr. W. F. Kirby, "Synopsis of Chalcididæ." 2. Mr. J. Starkie Gardner, "Eocene Representatives of Smilax in Great Britain." 3. Mr. F. Moore, "Lepidoptera of Mergui Archipelago." 4. Messrs. Forbes and Hemsley, "Chinese Plants." (II.) 5. Prof. P. M. Duncan, "Anatomy Test of *Discoidea cylindrica*."

Chemical, Burlington-house, W., 8 p.m 1. Professor H. McLeod, "The Electrolysis of Aqueous Solutions of Sulphuric Acid." 2. Dr. J H. Gladstone, "Essential Oils (Part III.), their Refractive and Dispersive Power." 3. Mr. J. M. H. Munro, "The Formation and Destruction of Nitrates and Nitrites in Artificial Solutions and in River and Well Waters." 4. Dr. W. H. Perkin, "An Apparatus for Distillation under Reduced Pressure." 5. Mr. A. P. Laurie, "The Electromotive Force produced by the Combination of Cadmium and Iodine in Presence of Water." 6. Prof. R. Meldola and Mr. F. W. Streatfeild, "A Method of Investigating the Constitution of Azo-, Diazo-, and Analogous Compounds."

Historical, 11, Chandos-street, W. 8 p m.

Numismatic, 4, St. Martin's-place, W.C., 7 p.m. Annual Meeting.

Friday, June 18...Colonial and Indian Exhibition, South Kensington, S.W., 3 p m. Conference of the Royal Colonial Institute. Captain J. C. R. Colomb, "Imperial Defence." 8 p.m. Mr. T. Wardle, "The Indian Silks in the Exhibition."

United Service Institute, Whitehall-yard, S.W., 3 p.m. Colonel C. E. Stewart, "The Use of Petroleum as Fuel in Steam Ships and Locomotives, based on its employment in that way on the Caspian Sea and in the Transcaspian Region."

Philological, University College, W.C., 8 p.m. Prof. Kuno Meyer, "The Syntax of the Teutonic Languages, especially Old-High-German and Anglo-Saxon."

Saturday, June 19...Colonial and Indian Exhibition, South Kensington, S.W., 3 p.m. Conference of the Geologists' Association. Prof. T. R. Jones, "South Africa."

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FRIDAY, JUNE 18, 1886.

All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

NOTICES.

ANNUAL GENERAL MEETING.

The Council hereby give notice that the One Hundred and Thirty-second Annual General Meeting, for the purpose of receiving the Council's Report and the Treasurer's statement of receipts, payments, and expenditure during the past year, and also for the election of officers and new members, will be held, in accordance with the Bye-laws, on Wednesday, the 30th June, at 4 p.m.

(By order of the Council)
H. Trueman Wood,
Secretary.

CONVERSAZIONE.

The Society of Arts Conversazione will be held, by permission of the Royal Commission, at the Colonial and Indian Exhibition, South Kensington, on Friday, the 16th of July next.

Each member will receive a card for himself, which will not be transferable, and a card for a lady. In addition to this, cards will be sold to members of the Society, or to persons introduced by a member, at the following prices:—Until the 3rd of July, 7s. each; after that date 10s. each, except on the 16th July, when the price will be 15s.

The Council, however, reserve the right of stopping the sale of tickets or of raising the price, if it is found necessary, in order to restrict the number of visitors within reasonable limits.

Tickets will only be supplied to persons presenting members' vouchers (forms of which can be obtained from the Secretary), or a letter of introduction from a member.

Members can purchase these additional tickets by personal application, or by letter addressed to the Secretary. In all cases of application by letter, a remittance must be enclosed. Each ticket will admit one person, either lady or gentleman.

Light refreshments (tea, coffee, ices, &c.) will be supplied at the usual buffets. No refreshments can be obtained by purchase. It will greatly facilitate the arrangements if members requiring additional tickets will apply for them at as early a date as convenient. The members' invitations are now in course of issue. Visitors' tickets can be purchased from the present date.

There will be no admission to the Exhibition on this evening except by special ticket, and no tickets can be purchased at the Exhibition.

Further particulars as to the arrangements will be announced in future numbers of the *Journal.*

Proceedings of the Society.

CANTOR LECTURES.

PETROLEUM AND ITS PRODUCTS.

By Boverton Redwood, F.I.C., F.C.S.

[The right of reproducing these lectures is reserved.]

Lecture I.—Delivered March 8th, 1886.

(Continued from p. 814).

The shales now employed in the Scottish works are found below the coal measures, chiefly in Midcalder, and are generally associated with marls, limestones, and sandstones. They are usually, as you see from the specimens on the table, of a brown or grey colour, the richer portions being soft to the touch, and the poorer hard and slate-like. They yield from 22 to 38 gallons of crude oil per ton.

Mr. John Fyfe, managing director of Young's Paraffin Oil Company, has kindly supplied me with samples of the following shales:—The Fell's or Addiewell, the Broxburn, and the Dunnet. The first is richest in crude oil, but yields comparatively little solid paraffin and ammonia, while the Dunnet shale yields these valuable products more largely than either of the other shales.

There are now a large number of shale oil refineries in successful operation in Scotland, the amount of shale distilled and of crude oil produced having, according to Mr. McGilchrist, increased from 800,000 tons, yielding 25,000,000 gallons of crude oil, in 1871, to 2,090,000 tons, yielding 62,712,000 gallons at the present time.

For some years the distillation of shale was also carried on to a considerable extent in Wales.

Mr. Samuel Findlater, until recently hon. secretary of the Scottish Mineral Oil Association, but now resident in Australia, has given me the following particulars of the mineral oil industry of New South Wales.

There are two companies engaged in the manufacture. The older, which has been in existence about twenty years, was formerly called the Western Kerosene Oil Company, but now goes by the name of the New South Wales Shale and Oil Company. The shale field worked by this company is situated at Hartley Vale, near the picturesque district of the Blue Mountains, on the Western Line; and the refinery is at Botany Bay. The distilling capacity of this company's plant is 400 tons of shale per week.

The more recently formed company, which has now carried on business about ten or twelve years, is termed the Australian Kerosene Shale and Oil Company. The mineral worked by this company is found at Joada Creek, near Mitteagong, about 80 miles south of Sydney, a private railway 18 miles in length running from the main line to the field. The mineral, which resembles Boghead coal, occurs in two seams of different qualities. The better quality, which yields 150 gallons of oil per ton, is sold principally for enriching gas; the lower quality, which gives 90 gallons of oil to the ton, is that which is distilled for mineral oil. This company distils about 200 tons of shale per week, and turns out about 750 gallons of burning oil per week.

Many valuable details of the development and progress of the petroleum and shale oil industries will be found in the pages of the *Oil Trade Review*, and the *Oil and Colourman's Journal*, both published in London, as well as in the *Oil, Paint, and Drug Reporter* and the *Independent Journal*, published in New York.

We now proceed to consider the geographical distribution of petroleum in localities where it has not yet been commercially used at all, or only on a comparatively small scale.

We have seen that petroleum has been found in coal mines in Derbyshire. It has also been found in coal measures in Shropshire, Lancashire, and Staffordshire; in a peat bog at Down Holland near Ormskirk, and in a limestone near Bristol. The indications of petroleum at Down Holland were thus described by Messrs. Binney and Talbot in a paper read before the Manchester Geological Society in 1843:—

> "The whole of the moss is in cultivation either under the plough or in grass, and has been so for at least forty or fifty years, and all, or the greater portion of it, lies at a lower level than the high water-mark of the sea at Formby. On approaching the place where the peat containing petroleum occurs, from Down Holland, the authors soon became aware of its presence by an empyreumatic smell, resembling that yielded by Persian naphtha, and the water in the ditches was also coated with a thin film of an oily iridescent fluid that floated upon its surface. In walking over some oat-stubble fields, and thrusting their heels through the black decomposed peat forming the soil, they felt a hard pitchy mass of three or four inches in thickness, which yields no smell unless it is burned. On exposure to the atmosphere for a time the pitchy matter lost the greater part of its inflammability, and was finally converted into black mould. This substance also occurred under the roots of the grass in old sward fields, but it then yielded an odour similar to the petroleum that floated on the surface of the water, and pervaded the moist peat."

A good deal of interesting information in reference to the existence of petroleum in Germany is to be found in the United States Consular reports. Attention has hitherto principally been directed to the Lünberger Heide district, known as the Oelheim belt, three miles north of Peine, on the Hanover and Brunswick Railway. This belt comprises about 25,000 acres, but the borings are at present confined to about 20 acres. In 1881 there were here twelve pumping wells in operation, yielding 1,250 barrels per week. Mr. George Henry Funck was recently good enough to ascertain for me, from Mr. Schütte, of Bremen, that at present there are in this district fourteen pumping wells in operation, with an aggregate production of 60 to 70 barrels of crude oil per day; and nine wells are in process of boring. In an instructive lecture delivered in Berlin before the Society for Promoting Commercial Industries in December last, Dr. Krämer stated that at a recent date the production of the Oelheim district had fallen to fifty barrels per day, but had since been slightly increased. Petroleum has also been found in

Alsace, on the Lower Rhine, at Schwabweiler, Pechelbronn, and at Lobsan; also near Carlsruhe, in the Grand Duchy of Baden.

The Roumanian petroleum deposits are situated in the north-east part of Wallachia, and southern part of Moldavia. The Wallachian district, which is the more important of the two, lies on the southern slopes of the Transylvanian Alps, the wells being situated six to twelve miles north of Plojeschti. The wells are of primitive construction, being simply dug. The crude oil is, in part, refined locally, and in part at Vienna, Pesth, and Odessa. The Moldavian district occupies a triangle, bounded by the rivers Taslen and Trotusch, not far from Adschud. The Galician oil fields have already been described.

Practically, the whole of the crude oil refined at Baku is obtained, as we have seen, from the Balakhani-Saboontchi district. It is, however, estimated that the petroleum deposits occur in Russia over an area of about 14,000 square miles, and there is little doubt that the 1,000, or 1,200 square miles of the Apsheron peninsula may be considered as more or less productive oil territory. Petroleum has already been obtained commercially at Kouban, about 60 miles inland from Novorossisk, on the shore of the Black Sea, and as far north-west as in the Crimea. In a United States' Consular Report, written in 1880, Mr. Peacock (who is now British Vice-Consul at Batoum) gave the number of wells in the Kouban district as thirty-four, and the annual yield of crude oil during the preceding eight years as more than 18,000 barrels. In the neighbourhood of Tiflis, and in many other places, there are petroleum pits and natural outflows of the oil. Near the Baku coast the sea is, in places, covered with a film of petroleum which has risen to the surface; and on the opposite side of the Caspian Sea there is said to be abundance of petroleum, some of which has already been used as fuel on the Trans-Caspian railway. On the island of Tcheleken, 200 miles from Baku, there are, apparently, immense deposits of ozokerit.

In Italy, petroleum is found in the provinces of Voghera, Piacenza, Parma, and Modena; also in the provinces of Chieti, east of Rome, on the Adriatic Sea, and of Caserta, on the Gulf of Tarentum. In Sicily, the oil has been found in the province of Girgenti.

Petroleum also occurs in Dalmatia and Albania.

In France, petroleum has been observed in the neighbourhood of Grenoble and elsewhere. Mons. F. M. Piret, of Grenoble, mining engineer, informs me that he commenced drilling a well in that locality in 1879, but in consequence of various difficulties, a depth of only 140 metres was reached; and the ground level being 720 metres above that of the sea, it is expected that the well must be very much deepened before oil is reached. The spot where the drilling is in progress is, adds Mons. Piret, termed La Fontaine Ardente, and was celebrated in Julius Cæsar's time for the quantity of natural gas emitted from the ground. Deposits of asphalt have also been found in France.

In Switzerland, as is well known, extensive deposits of asphalt occur.

In Denmark, and in Sweden, bituminous mineral and semi-solid pretroleum have been found.

In Asia petroleum occurs in Asia Minor, in Persia, in Hindostan, in Burmah, in China, and in Japan, as well as in the islands of the Indian Archipelago. Some of these deposits are of historical interest, and have already been referred to.

The Rev. J. N. Cushing, who visited Burmah in 1881, states that in that year there were about 200 wells lying about three miles east of the town of Yenangyoung, on the river of the same name. This town is about 400 miles north of Rangoon. Petroleum is also found in the islands of Ramri and Cheduba, the Barangah Islands, and others off the coast of British Burmah. Much valuable information, in regard to the latter deposits, will be found in the records of the Geological Survey of India.

The petroleum wells in China occur in the province of Sse-tchouen, and are thus described by L'Abbé Huc:—

> "When a salt well has been dug to a depth of 1,000 feet, a bituminous oil is found in it that burns in water. Sometimes as many as four or five jars of 1,000 pounds each are collected in a day. This oil is very fœtid, but it is made use of to light the sheds in which are the wells, and the cauldrons of salt. The mandarins, by order of the prince, sometimes buy thousands of jars of it, in order to calcine rocks under water that render navigation perilous."

We have already seen that the Chinese have for ages employed natural gas for heating purposes. The gas is conveyed long distances in bamboo tubes, terminating in a clay or porcelain burner.

The petroleum deposits and petroleum industry of Japan have been very minutely described by Mr. Lyman in reports published in connection with the Geological Survey of Japan. In 1877, Mr. Lyman stated that there were in the Echigo oil-fields 522 productive wells, yielding a total of about 9,500 barrels of petroleum per annum; and in the province of Shinano 22 productive wells, yielding a total of 1,900 barrels.

There are several localities in Africa where the surface indications of petroleum are distinct. Attention has recently been directed to the results of a boring at Jemseh, on the west coast of the Red Sea, at the entrance of the Gulf of Suez, and it seems probable that both at this place and at Gebel-el-Zeit, large quantities of petroleum may be obtained. Regarded as liquid fuel, this Egyptian petroleum may, from the geographical position of the deposits, prove to be of great value.

In the West Indies petroleum has long been known to exist. The petroleum of Barbadoes was formerly imported under the name of Barbadoes tar, and the asphaltum, from the celebrated Pitch Lake of Trinidad, has also been an article of commerce. This lake is about three miles in circumference, and is described as a mass of asphaltum firm enough to bear a team of horses, but still somewhat plastic, and appearing to be in motion towards certain vortices, as the trunks of trees disappear, and after a time emerge at some distance from the point at which they sank. Small lakes and streams of water, abounding in fish, are distributed over the surface, with numerous islands covered with tropical verdure. Petroleum and asphalte also occur in Cuba. In Java and Sumatra, petroleum, which issues from natural fissures or artificial excavations, is an article of commerce among the natives.

I am indebted to Mr. Findlater for calling my attention to the following reference to the petroleum springs in New Zealand, published in 1884 by Mr. G. W. Griffin, United States Consul at Auckland:—

> "While returning to Auckland, I touched at Napier, where I found many elements of prosperity. I left Napier by steamer in the evening, and arrived at Gisborne the following day. I drove out to the petroleum oil springs about thirty miles from that town. Several companies have been organised for working these springs, and boring for oil, but as yet they do not appear to have met with any great success."

From Mr. Griffin's description, it appears that there are three kinds of petroleum in New Zealand. The first variety is obtained at the Sugar-loaves, in the Taranaki district. It has a specific gravity, of ·960 to ·964, and yields an excellent lubricating oil. The second is found at Poverty Bay, on the east coast of the Auckland district. The third occurs at Manutahi, Waipu, east coast. This is the best of the three as a source of burning oil, and is stated to yield 84 per cent. of this product.

In South America, asphalt and petroleum have been found in various localities. Mr. Prentice, in 1867, commenced the development of the petroleum deposits near Zorritos in Peru, and in 1876 he struck a very productive flowing well in this locality and erected a refinery, but the outbreak of war soon afterwards put a stop to the industry. In Venezuela extensive deposits of petroleum are stated to exist on the shore of lake Maracaibo.

In British America petroleum occurs in Newfoundland, Nova Scotia, New Brunswick, and elsewhere, in quantities that hitherto have not been considered to render the sources worth developing. The Canadian petroleum deposits have already been referred to.

Petroleum also occurs in Mexico.

I have reserved to the last the consideration of the geographical distribution of petroleum in the United States. The principal deposits have already been referred to in describing the growth of the American petroleum industry. Solid bitumen occurs in the States of Connecticut, New York, New Jersey, West Virginia, Texas, New Mexico and Arizona, Utah, California, Kentucky, Tennessee and others; semi-solid bitumen in north-east Texas and southern California; and liquid and gaseous petroleum not only as we have seen in New York and Pennsylvania, Ohio, and West Virginia, Kentucky and Tennessee, but also in Alabama, Florida, Michigan, Illinois, Indiana, Missouri, Kansas, Louisiana, Nebraska, Montana, Wyoming, Dakota, Colorado, and New Mexico, as well as in California.

Mr. Peckham states that petroleum, including its solid and gaseous forms, occurs:—

> "On the American continent along a line extending from Point Gaspé, in Canada, to Nashville, Tennessee, and in Europe-Asia along a line extending from Hanover, on the North Sea, through Galicia, the Caucasus, and the Punjab. These are the principal lines. In America it also occurs on the Pacific Coast, from the bay of San Francisco to San Diego; again, from northern Nebraska to the mouth of the Sabine River, on the Gulf of Mexico; again, from Havana near the western end of Cuba

through San Domingo, and the circle of the Windward and Leeward Islands, to Trinidad; thence westward on the mainland to the Magdalena River, and southward from that point to Cape Blanco, in Peru. In Europe-Asia bitumen occurs on the lower Rhine, and in the valley of the Rhone; from northern Italy, following the Appenines, to southern Sicily; along the eastern shores of the Adriatic, through Dalmatia and Albania, into Epirus; again, along the depression in which lies the Jordan and the Dead Sea; again, along the mountains that border the valley of the Tigris in the east; again, from western China, through Burmah, Pegu, Assam, Sumatra, and Java; and lastly, in Japan. It will be observed that these lines are, for the most part, intimately connected with the principal mountain chains of the world."

We have now to consider the geological aspect of our subject, and in doing so we can avail ourselves of the valuable Pennsylvania Geological Survey Reports of Mr. John F. Carll, and the elaborate Census Report of Mr. Peckham, to which I have already referred. Petroleum occurs in all geological formations from the Silurian up to the Tertiary, though as Mr. Peckham points out, this statement requires qualifying by the statement that the occurrence is confined mainly to the Silurian formation, and to the lower half of the Tertiary. Thus, in the western hemisphere the oil is found chiefly in the Silurian and Devonian rocks, while in the eastern hemisphere it is for the most part found in the Eocene or Miocene formation.

In the United States petroleum exists, saturating strata of sand-rock. When first wells were drilled in America nothing was known about these strata; but ultimately, in the valley of Oil Creek, the existence of three well-defined oil sands was ascertained. These oil sands in the Oil Creek district are of considerable regularity as regards their thickness and the intervening distance between them, the first sand being 40 ft. thick, with an interval of 105 ft. between it and the second sand, which is 25 feet thick; an interval of 110 ft. occurring between the second sand and the third, the thickness of the latter being 35 ft. In some localities, however, the second sand is split into two well-defined sands, with from 15 ft. to 30 ft. of slates or shales intervening, and this has given rise to the definition of a fourth sand. In drilling on high ground in the Oil Creek district, several upper sand rocks were also perforated; these were termed "mountain sands." In addition to the three regular sands, there was often found, about 15 ft. to 20 ft. above the regular third, a fine-grained muddy gray sand, from 12 ft. to 25 ft. thick; this was termed the "stray third."

The Venango oil sand group is described by Mr. Carll as a group in the strictest sense of the term, having a well-defined top and bottom, and consisting of a mass of sandstone deposits from 300 to 380 feet thick, with layers of pebbles and many local partings of slate and shale. These figures may, he states, be varied somewhat, but it will be found, as a general rule, that a thickness of 350 feet will, in nearly every case, embrace all the sands belonging to the Venango group, even the fourth, fifth, and sixth sands, as the lower members of the group in some localities have been called. The oil is principally obtained in the third sand.

As the area of the oil-producing territory was extended, it was found that the underlying geological formation varied considerably, the sand-rock disappearing, and its place being taken by shales at the same geological horizon.

The several groups of oil producing rocks are, as Mr. Carll remarks, locally well-defined under certain areas; but they have their geographical as well as their geological limits, and as far as is at present known, the geographical limit of one group never overlaps that of another. Hence, it must not be presumed that each particular sandstone or its oil will be found in every locality where its horizon can be pierced with the drill, or that a measured section of the rocks in one place can be precisely duplicated in detail in another. Therefore the most skilful oil-producer, the most expert geologist, cannot tell how many other oil horizons may exist at intermediate depths beneath the surface (*i.e.*, in the scale of the formation), but which have, as yet, escaped the oil-miner's drill.

In Western Pennsylvania, the sand rock, specimens of which I have on the table, varies in character from a coarse-grained uncemented sandstone, to a pebble conglomerate, composed of coarse pebbles, of white, or slightly coloured opaque quartz, overlaid by marls and slates, often highly silicated, forming very hard and impervious crusts. This pebble conglomerate consists of two varieties, occupying separate horizons, in one of which the pebbles are nearly spherical, and in the other flattened. Between these beds of sandstone or conglomerate that contain the oil are beds of shale, with which are thin beds of sand and "shells." These shells are described by Professor Leslie as hard crusts of white flint.

Mr. Peckham remarks that petroleum is found in the principal producing territories in the United States and Canada, saturating porous strata, and overlying superficial gravels; it occurs in Canada and West Virginia beneath the crowns of anticlinals; while in Pennsylvania it occurs saturating the porous portions of formations that lie far beneath the influence of the superficial erosion, like sand-bars in a flowing stream or detritus on a beach. These formations or deposits, taken as whole members of the geological series, lie comformably with the enclosing rocks, and slope gently toward the south-west. The Bradford field in particular, says Mr. Peckham, resembles a sheet of course-grained sandstone, 100 square miles in extent, by from 20 to 80 feet deep, lying with its south-western edge deepest, and submerged in salt water, and its north-eastern edge highest, and filled with gas under an extremely high pressure.

In relation to the geology of natural gas, Mr. Ashburner points out that the oil and gas regions of Pennsylvania are shown by the strata drilled by the gas-wells in the neighhood of Pittsburg to be one in a geological sense. The general conditions upon which the occurrence of natural gas seems to depend, from a consideration of the facts at present at our command, are (*a*) the porosity and homogeneousness of the sandstone which serves as a reservoir to hold the gas; (*b*) the extent to which the strata above or below the gas-sand are cracked; (*c*) the dip of the gas-sand, and the position of the anticlines and synclines; (*d*) the relative proportions of water, oil, and gas contained in the gas-sand; and (*e*) the pressure under which the gas exists before being tapped. Other conditions may, however, as Mr. Ashburner remarks, be still discovered, which will have as important a bearing upon the problem as those which have been stated.

Vasilieff, who published an article on the "Oil Wells of Baku," in the *Russian Mining Journal*, for September last, an abstract of which, by Mr. William Anderson, has recently appeared in the Minutes of the Proceedings of the Institution of Civil Engineers, states that the petroleum bearing strata of the Caucasus belong to the lower Miocene series of the Tertiary epoch, the deposits extending in a N.E. to S.W. direction, and the dip ranging apparently between 20° and 40°. The petroleum-bearing beds are composed of sand, calcareous clays, marls, and in places, compact sandstone, often of great thickness, penetrated by bands of pyrites. The number of oil-bearing strata is unknown, but three oil-sands have, up to the present time, been defined.

Petroleum is generally considered to have resulted from the slow decomposition of vegetable or animal matter, either in the rocks in which it is found, or in underlying strata. Berthelot, however, in 1866, propounded the theory that petroleum was formed by the action of carbonic acid and steam on the alkali metals; and in the following year Mendelejeff, in a celebrated essay, read before the Chemical Society of St. Petersburg, and subsequently published in the *Revue Scientifique*, gave in detail his reasons for believing petroleum to be the product of the action of water upon iron or other metal, and carbon, at a high temperature and under great pressure.

The view that petroleum is indigenous to the rocks in which it is found has been strongly supported by Dr. Hunt and Professor Leslie. Mr. Peckham, after a prefatory remark that his studies, extending over twenty years, have led him to the conclusion that, as yet, very little is known regarding the chemical geology of petroleum, expresses the opinion that all bitumens, from the solid to the gaseous, have, in their present condition, originally been derived from animal or vegetable remains, but that the manner of their derivation has not been uniform. Referring to the hypothesis that petroleum is indigenous in the rocks in which it is found, and to that which regards all bitumens as distillates, he remarks that there remains the modifying fact that there are four kinds of bitumen:—

1. Those bitumens that form asphaltum and do not contain paraffin.

2. Those bitumens that do not form asphaltum and contain paraffin.

3. Those bitumens that form asphaltum and contain paraffin.

4. Solid bitumens that were originally solid when cold or at ordinary temperatures.

The first class includes the bitumens of California and Texas, doubtless indigenous in the states in which they are found; and probably also some of the bitumens of Asia.

Too little is known, Mr. Peckham adds, about petroleum at the present time to enable anyone to explain all the phenomena on any hypothesis, but it seems to him that the varieties of petroleum found in New York, Pennsylvania, Ohio, and West Virginia are distinctly of vegetable origin, and are the product of fractional distillation, as shown by the large amount of paraffin in the Bradford oil, under the enormous pressure to which it it subjected; while the Kentucky and Californian oils are evidently of animal origin, and have not been subjected to distillation. It is not, he considers, the effects of heat as represented by volcanic action that have produced the petroleum, but rather the effects of slow and gentle changes at low temperatures, due to metamorphic action upon strata buried at immense depths. Regarding the nature of the metamorphic action, he states that it is sufficient for our purpose to know that from the upper Silurian to the close of the Carboniferous periods, the currents of the primeval ocean were transporting sediments from north-east to south-west, sorting them into gravel, sand, and clay, forming gravel bars and great sand beds beneath the riffles and clay banks, in still water, burying vast accumulations of seaweeds and sea animals far beneath the surface. The alteration, due to the combined action of heat, steam, and pressure, that resulted in the formation of the Appalachian system, from Point Gaspé, in Canada, to Look-out Mountain in Tennessee, involving the carboniferous and earlier strata, distorting and folding them, and converting the coal into anthracite, and the clays into crystalline schists along their eastern border, could not have ceased to act westward along an arbitrary line, but must have gradually died farther and farther from the surface. The great beds of slate and limestone containing fucoids, animal remains, and even indigenous petroleum, must have been invaded by this heat action to a greater or less degree, and thus, in accordance with the theory of Professor Leslie, a chronic evaporation or distillation of the whole mass of oil in the crust of the earth (within reasonable reach of the surface) has been going on, converting the animal and plant remains into oils, the light oils into heavy oils, the heavy oils into asphalte and albertite; the process being accompanied with the liberation of gas. Dealing, in connection with this theory, with the objection of those who, supporting Berthelot's and Mendelejeff's views, point out that there is no evidence of the action of heat upon the rocks holding the oil, and no residues of fixed carbon, Mr. Peckham replies that we must seek the evidences of heat action at a depth far below the unaltered rocks in which the petroleum is now stored. If petroleum, he adds, is the product of a "purely chemical process," we should not expect to find paleozoic petroleums of a character corresponding with the simple animal and vegetable organisms that flourished at that period, and tertiary petroleums containing nitrogen, unstable and corresponding with the decomposition products of more highly organised beings, but we should expect to find a general uniformity in the character of the substance, wherever found, all over the earth.

The subject, while one of speculation, is one that obviously is of practical importance, as affecting the sources and duration of supplies of petroleum, its profitable development, and commercial permanence.

Petroleum occurs, as we have seen, in all forms, from the gaseous to the solid. In its liquid form it varies greatly in physical properties, as well as in chemical composition, and in regard to the proportion of the different commercial products yielded on distillation. The ordinary extent of variation in specific gravity, colour, and odour is shown in the Table which I have compiled from my notes of the examination of typical samples. In a succeeding lecture I shall have to call attention to the important differences in the yield of commercial products in the cases of certain of these samples.

Date of Examination.	Locality.	Sp. Gr.	Colour (by transmitted light), &c.
1870	Barbadoes	·957	Tarry appearance and consistency.
1873	Persia	·777	Straw colour; strong and disagreeable odour.
1877	India	·829	Amber colour; pleasant odour.
1878	Canada	·865	Dark brown colour; offensive odour.
1878	Burmah (mud volcano, Kyouk Phyou)	·818	Reddish-brown colour; slight and pleasant odour.
1878	Burmah (Minbyin, native pits)	·866	Dark brown colour; slight and pleasant odour.
1878	Burmah (Western Barangah)	·888	Chestnut brown colour; slight and pleasant odour.
1878	Burmah (Eastern Barangah)	·835	Dark brown colour; slight and pleasant odour.
1878	India (Assam)	·933	Dark brown colour; viscid; slight and pleasant odour.
1879	United States (Bradford district)	·810	Reddish-brown colour.
1880	India	·935	Very dark brown colour; viscid.

Date of Examinations.	Localities.	Sp. gr.	Colour (by transmitted light), &c.
1880	Russia	·836	Dark reddish-brown colour; mobile; slight and pleasant odour.
1880	Russia	·942	Brownish-black colour; viscid; very little odour.
1881	Hanover	·843	Dark brown colour; slight and pleasant odour.
1882	South America	·852	Dark reddish-brown colour; little odour.
1882	South America	·900	Dark brown colour; somewhat viscid; scarcely any odour.
1883	New Zealand	·828	Brownish colour; little odour.
1884	Oelheim	·913	Brownish-black colour; rather disagreeable odour.
1885	Italy (near Milan)	·787	Straw colour; pleasant odour.
1885	United States (Wyoming)	·910	Black colour; disagreeable odour.
1885	United States (Wyoming)	·945	Black colour; disagreeable odour.

Dr. Krämer gives ·780 and ·970 as the extreme limits of variation in the specific gravity of liquid petroleum; and in illustration of the well-known fact that contiguous wells often yield oils of very different quality, instances the case of two wells in the Oelheim district, of the same depth, and within two metres of each other, one of which yields an oil of sp. gr. ·880, and the other an oil of sp. gr. ·905.

Besides the samples referred to, I have on the table a very fine collection of crude petroleums from different parts of the world. Among the specimens I have recently received from America are crude oils from the following districts:—Macksburg, sp. gr. ·829; Parker (Karns city), sp. gr. ·789; Parker (Clarion), sp. gr. ·797; Bradford, sp. gr. ·810; Stoneham, sp. gr. ·802; Thorn Creek, sp. gr. ·802. Of these oils, Parker (Karns city and Clarion), Stoneham, and Thorn Creek are classed together, while Bradford and Macksburg are of a different class.

For the samples of Baku crude oil I am indebted to Professor Dewar; and for that of Oelheim petroleum to Dr. Krämer, of Berlin.

The material known as "ozokerit," large quantities of which are exported from Galicia, may be described as native paraffin wax. I have on the table some fine specimens of ozokerit with which Mr. Leopold Field has supplied me. Immense deposits of a similar material are, as I have said, stated to exist in the island of Tcheleken on the Trans-Caspian coast. In Boryslaw and Stanislaw (Galicia) the ozokerit occurs partly in beds and partly in pockets in the miocene formation, and is obtained in small pieces or in masses of several hundred pounds weight.

Crude petroleum, in the liquid form, consists almost entirely of carbon and hydrogen, usually in the proportion of about 85 per cent. of the former, to 15 per cent. of the latter, but there are also sometimes present in small quantity oxygen, nitrogen, and sulphur.

Reichenbach examined paraffin in 1824, and rock oil ten years later. Early attempts to determine the composition of petroleum were also made by Laurent. In 1857, De La Rue and Müller described the products they had obtained from Rangoon petroleum. In 1863, Schorlemmer isolated some of the constituents of American petroleum, and about the same time Pelouze and Cahours succeeded in separating from this oil twelve distinct hydrocarbons, which were found to be homologues of marsh gas (CH_4), and of which the general formula is $C_n H_{2n+2}$.

Of the more volatile hydrocarbons, viz., those boiling between 0° C. and 130° C. there have been shown to be two series present, those of the first series which have the higher boiling points being normal, while those of the second agree for the most part in boiling point with the corresponding synthetically prepared isoparaffins. There are grounds for belief in the occurrence of a third series of paraffins in the fraction referred to. From the crude oil, as it issues from the earth, methane, ethane, and propane are given off in gaseous form, so that from American petroleum the paraffins referred to in the Table on p. 825 have been separated.

Methane is a colourless inodorous gas, burning with a yellow flame of little luminosity. Ethane is also a colourless, odourless gas. Propane liquifies at —20° C. Normal butane condenses at 0° C. to a liquid, boiling at 1° C., which constitutes the greater part of the petroleum product known as "cymogene." Normal pentane occurs with iso-pentane in the most volatile portion of petroleum spirit. Hexane, heptane, octane, and certain of their isomers constitute the greater part of the liquid known as "benzoline."

The less volatile portions of American crude petroleum, boiling above 260° C., contain

	Specific Gravity.	Boiling Point.	
	Normal	Normal.	Iso.
Methane—CH_4			
Ethane—C_2H_6			
Propane—C_3H_8			
Butane—C_4H_{10}	......	0	——
Pentane—C_5H_{12}	0·645 at 0° C.	38° C.	30° C.
Hexane—C_6H_{14}	0·63 ,, 17° C.	69° C.	61° C.
Heptane—C_7H_{16}	0·712 ,, 16° C.	98° C.	91° C.
Octane—C_8H_{18}	0·726	124° C.	118° C.
		Boiling Point.	
Nonane—C_9H_{20}	0·741 ,, 15° C.	136° to 138° C.	
Decane—$C_{10}H_{22}$	0·757 ,, 15° C.	160° ,, 162° C.	
Endecane—$C_{11}H_{24}$	0·765 ,, 16° C.	180° ,, 184° C.	
Dodecane—$C_{12}H_{26}$	0·776 ,, 20° C.	196° ,, 200° C.	
Tridecane—$C_{13}H_{28}$	0.792 ,, 20° C.	216° ,, 218° C.	
Tetradecane—$C_{14}H_{30}$	......	236° ,, 240° C.	
Pentadecane—$C_{15}H_{32}$	......	255° ,, 260° C.	

paraffins of still higher order, those containing 20 per cent. of carbon atoms, or more, being crystalline solids. There are also present hydrocarbons of the $C_n H_{2n}$ series, which, however, according to Markownikow, who terms them naphthenes, differ from the olefines. Dr. Krämer, who has exhaustively examined three varieties of German petroleum, inclines to the belief that the so-called naphthenes are mixtures of paraffinöid and benzenöid hydrocarbons.

From the least volatile portion of American crude petroleum a peculiar solid crystalline hydrocarbon was separated by Morton in 1873. To this hydrocarbon, which in its reactions resembled impure anthracene, the name of "thallene" was given. Morton subsequently found that the spectrum of "thallene" differed from that of impure anthracene. This product was subsequently examined by Prunier; and more recently by Dr. Divers and Mr. Nakamura, who have isolated a body of the formula $(C_4H_3)_n$ boiling between 280° and 285° C.

In 1875, Hell and Meidinger obtained from Wallachian petroleum an acid, forming alkali-salts resembling soft soap. The analysis of the acid, the ether, and the silver-salt, agreed best with the formula $C_{11}H_{20}O_2$. These chemists expressed the opinion that heavy Wallachian petroleum contains a series of probably homologous acids. Markownikow has found in a fraction of Russian petroleum, boiling between 220° and 230° C., as much as 5·25 per cent. of oxygen. This chemist, continuing the research of Hell and Meidinger, ascertained the occurrence also of bodies of a phenolöid character. Dr. Krämer has recently examined the oxygenated bodies present in German petroleum.

Caucasian petroleum has, during the past few years, been the subject of much research at the hands of several chemists, among whom may be mentioned Markownikow and Oglobine, and it has been shown that this material is altogether different in composition from American petroleum, and that it consists for the most part of hydrocarbons of the $C_n H_{2n}$ series, isomeric both with the olefines, or true homologues of ethylene, and with the hexhydrides of the benzenes. The hydrocarbons in question exhibit the closest resemblance to the paraffins, but are of higher density than their isologues. They are attacked by chlorine, yielding chlorinated derivatives; but on oxidation are completely destroyed, without furnishing characteristics products. The following is a list of the hydrocarbons of this group, which have been separated from Caucasian petroleum:—

	Boiling point.
C_8H_{16}	119° C.
C_9H_{18}	136° ,,
$C_{10}H_{20}$	161° ,,
$C_{11}H_{22}$	180° ,,
$C_{12}H_{24}$	196° ,,
$C_{14}H_{28}$	240° ,,
$C_{15}H_{30}$	247° ,,

Ethylene (C_2H_4), which appears to be the lowest member of the series of olefines capable of existing in the separate state, is at ordinary temperatures and pressures a colourless gas, burning, as you see, with a luminous white flame.

Hydrocarbons of the aromatic ($C_nH_{2n} - 6$) series are also found in petroleum. Pawlewski reports that a volatile product of the distillation of Galician petroleum, examined by him, contained as much as 4·9 per cent. of hydrocarbons of this group.

The burning oil obtained from American petroleum contains a considerable proportion of olefines, produced from the paraffins, as I shall have occasion to show in a subsequent lecture, by the process of "cracking."

I am indebted to Professor Nason, of Troy, New York State, for a valuable list of references to various articles published on the chemistry of petroleum.

The following tabular statement is based upon the analyses of natural gas made by Mr. Carnegie, at his works near Pittsburg, and quoted by Professor Dewar in a paper read in this theatre last May:—

Composition of Six Samples of Natural Gas.

	1.	2.	3.	4.	5.	6.
	per cent.	per cent.	per cent.	per cent.	per cent.	per cent.
Marsh gas	72·18	65·25	60·70	49·58	57·85	75·16
Hydrogen	20·12	26·16	29·03	35·92	9·64	14·45
Ethylic hydride	3·6	5·5	7·92	12·30	5·20	4·8
Olefiant gas	·7	·8	·98	·6	·8	·6
Oxygen	1·1	·8	·78	·8	2·1	1·2
Nitrogen	nil.	nil.	nil.	nil.	23·41	2·89
Carbonic acid	·8	·6	nil.	·4	nil.	·3
Carbonic oxide	1·0	·8	·58	·4	1·0	·6

The co-efficient of expansion of crude petroleum varies according to the proportion of the more volatile hydrocarbons present, as is shown in the following Table:—

Sp. gr. at 15° C.	Expansive co-efficient for 1° C.
Under ·700	·00090
·700 to ·750	·00085
·750 to ·800	·00080
·800 to ·815	·00070
Over ·815	·00065

The rate of expansion has also been found to vary according to the temperature.

In practice it is customary to add to or subtract from the observed specific gravity ·004 for every 10° F. above or below 60° F., and this is found to afford a sufficiently close approximation to the truth for all commercial purposes in the case of all the ordinary petroleum products.

Tables for calculating the alterations in volume of crude petroleum with accuracy, are in use in America. These Tables were constructed on Gay Lussac's formula—

$$\frac{1 + kt}{1 + at} = \frac{P - p}{P}$$

where P = weight of fluid before heating it;
p = weight of the fluid after heating, and after the apparent expansion has been removed;
t = change of temperature;
k = co-efficient of expansion of the glass;
a = co-efficient of expansion of the fluid.

Miscellaneous.

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COLONIAL AND INDIAN EXHIBITION.

The following are the arrangements for Conferences after Whitsuntide, so far as decided. The dates are subject to revision. The meetings are open to all visitors to the Exhibition:—

Thursday, June 17.—A. Wilmot. Paper, "Commercial Condition of Cape Colony." 4 p.m.

Friday, June 18.—Conference of the Royal Colonial Institute. Paper, "Imperial Defence," Capt. J. C. R. Colomb. 3 p.m.

Saturday, June 19.—Conference of the Geologists' Association. "South Africa," Prof. T. R. Jones, F.R.S. 3 p.m.

Monday, June 21.—W. Senior. Paper, "The Colony of Queensland." 4 p.m.

Tuesday, June 22.—Conference of the Anthropological Institute. "Races of Australia." 4 p.m.

Wednesday, June 23.—W. Lant Carpenter. Paper, "The Position of Science in Colonial Education." 4 p.m.

Thursday, June 24.—Conference of the Central Emigration Society. "Emigration from Colonial Point of View." 11 a.m. "The Best Method of Colonisation." 3 p.m. T. Wardle. Paper, "The Indian Silks in the Exhibition." 8 p.m.

Friday, June 25.—Conference of the Central Emigration Society. "The Duty of the Church towards Emigration." 11 a.m. "Emigration of Children." 3 p.m. F. W. Pennefather. Lecture. "Natives of New Zealand," with lime-light illustrations. 8.30 p.m.

Saturday, June 26.—Dr. H. Trimen. Paper, "The Vegetation of Ceylon." 4 p.m.

Monday, June 28.—Joseph Bosisto, President of the Royal Commission for Victoria. Lecture, "Australian Vegetation, with special reference to the Eucalypti." 8 p.m.

Tuesday, June 29.—Conference of the Anthropological Institute. "Races of New Zealand." 4 p.m.

Wednesday, June 30.—Dr. W. Fream. Paper, "Colonial Forestry." 4 p.m. Major Craigie. Paper, "Home, Foreign, and Colonial Sources of Meat Supply." 8 p.m.

Thursday, July 1.—Conference of the Imperial Federation League. "Imperial Federation." 4 p.m.

Friday, July 2.—Conference of the Imperial Federation League. "Imperial Federation." 4 p.m. W. H. P. Greswell, M.A. Paper, "Advance of Civilisation and Education in Cape Colony." 8 p.m.

Saturday, July 3.—Conference of the Geologists' Association. "Canada." Dr. A. R. Selwyn. 3 p.m.

Monday, July 5.—Conference of the Anthropological Institute. "Races (Aboriginal) of India." 4 p.m. R. L. Nash. Paper, "Trade and Commerce of Queensland." 8 p.m.

Tuesday, July 6.—*Congress of the Chambers of Commerce of the Empire. 10 a.m.

Wednesday, July 7.—*Congress of the Chambers of Commerce of the Empire. 10 a.m.

Thursday, July 8.—*Autumnal Meeting of the Chambers of Commerce of the United Kingdom who are Members of the Association of Chambers of Commerce. 10 a.m.

Friday, July 9.—J. Sivewright. "Colonial Telegraphs." 4 p.m.

Monday, July 12.—Sir Robert Biddulph, G.C.M.G. Paper, "Cyprus." 4 p.m.

Tuesday, July 13.—Conference of the Anthropological Institute. "Races of Ceylon; Straits Settlements; Borneo." 4 p.m.

Wednesday, July 14.—Prof. Leone Levi. Paper, "Wages of Labour in Relation to Cost of Living." 4 p.m.

Saturday, July 17.—Conference of the Geologists' Association. "New Zealand." Dr. J. Von Haast, F.R.S. 3 p.m.

At the Conferences marked with an asterisk (*) the admission will be confined to Delegates of Chambers of Commerce.

The number of visitors to the Exhibition for the week ending June 12th, was 159,715; making a total since the opening of 873,569.

GREENWICH OBSERVATORY.

The annual visitation of the Royal Observatory was held on Saturday, June 5th, when the report of the Astronomer Royal was presented to the Board of Visitors.

Reference was made in the last report to a new instrument for determining absolute personal equations (see *Journal*, vol. xxxiii. p. 841), and Mr. Christie now reports as follows respecting its use:—"The personal equation instrument was completed last autumn, but was dismounted during the winter to preserve it from injury in the bad weather. Series of observations have been taken with it on five days, and the results appear to be very satisfactory, the accordance being as close as could be expected. The absolute personal equations thus obtained seem to show that all the observers observe too late, the differences between the several observers agreeing well with the relative personal equations found from observations of clock-stars."

According to the report—"In the twelve months ending May 20th, 1886, photographs of the sun have been taken on 205 days, and of these 410 have been selected for preservation, besides 10 photographs with double images of the sun for determination of zero position. There were 12 days on which the sun's disk was observed to be free from spots.

"The areas of both spots and faculæ have shown a marked diminution in 1885 as compared with 1884, the mean daily area for 1885 being in each case only three-fourths of that for the previous year. The diminution in the spotted area has taken place principally in the northern hemisphere."

"The mean temperature of the year 1885 was 48°·6, being 0°·7 lower than the average of the preceding 44 years. The highest air temperature (in the shade) was 90°·2 on July 26, and the lowest 22°·3 on January 22. The mean monthly temperature was above the average in February and July, and below in January, March, May, August to October, and December. As regards the long-continuing cold weather this spring:—The mean temperature for the whole period 1886 January 5 to March 18 was 33°·8, being 5°·9 below the average; for the period February 1 to March 18, 33° 2, 6°·9 below the average; and for the period March 1 to 18, 32°·6, 8°·2 below the average. The mean temperature for the month of February was 33°·7, which thus compares with the previously recorded low temperatures for the same month in other years:—1845, 32°·7; 1853, 33°·3; 1855, 29°·1; 1858, 34°·6; 1873, 34°·3. The lowest temperature recorded this spring was 16°·5 on 1886 January 7.

"The mean daily motion of the air in 1885 was 287 miles, being three miles greater than the average of the preceding 18 years. The greatest daily motion was 704 miles on January 11, and the least 71 miles on November 12 and December 26. The only recorded pressure exceeding 20 lbs. on the square foot in 1885 was 22·5 lbs. on January 10.

"The number of hours of bright sunshine recorded by Campbell's sunshine instrument during 1885 was 1,261, which is about 60 hours more than the average of the preceding eight years. The aggregate number of hours during which the sun was above the horizon was 4,455, so that the mean proportion of sunshine for the year was 0·283, constant sunshine being represented by 1. A register of sunshine has also been regularly obtained from the beginning of

June to the end of December last year with Jordan's recorder. A comparison of the results with the two instruments for the month of June, 1885, shows 222 hours of sunshine registered by Jordan's recorder, and 212 hours by Campbell's.

"The rainfall in 1885 was 24·0 inches, being 0·8 inch below the average of the preceding 44 years."

General Notes.

Railway Accidents in France. — During 1883, the total number of passengers carried by the French railways was 207,171,029 (the total length of the railways of France being 22,092 kilometres 13,697 miles.) Of this number, only 42 passengers were killed, and 279 injured; that is to say, 1 killed for every 4,993,399, and one injured for every 742,554.

Imports of Coal and Iron to Italy.—During the first three months of the present year the imports of iron and coal were, as compared with the similar periods of the two preceding ones as follows:—

	1884.	1885.	1886.
Iron	19,620 tons	15,112 tons	21,975 tons.
Rails	3,635 ,,	527 ,,	750 ,,
Machinery	£98,300	£147,600	£125,400
Coal	514,600 ,,	684,100 ,,	656,000 ,,

Havre International Exhibition.—An International Maritime Exhibition is announced to be held at Havre, from 1st May to 30th September, 1887, embracing all branches of industry connected with navigation, fishing, and electricity. The idea of this Exhibition was started by the General Commercial Syndicate, with the co-operation of the Havre Municipality and Chamber of Commerce, and is under the patronage of the French Ministers of the Marine and Colonies, and of Commerce and Industry, Application for space must be made before 1st January, 1887, to the Direction de l'Exposition Maritime Internationale, 118, Rue de Paris, Havre, France.

Belgian Mail Service.—While late letters between England and Belgium go *viâ* Calais, the bulk of the mails are carried by steamers belonging to the Belgian Government between Dover and Ostend. To shorten the time occupied by this passage, the Belgian Government has ordered from the John Cockerill Company, of Seraing, three steamers of a type common on the Volga, having a high speed and but slight draught of water, so that they can enter the harbours at all states of the tide. The first of the steamers, *The Albert*, was launched on June 2nd, from the Cockerill Company's Hoboken Shipyard, near Antwerp, in the presence of the Belgian Minister of Railways, Posts, and Telegraphs. Her length between perpendiculars is 255 ft., and B.M. 1,062 tons; breadth outside paddle-boxes, 35 ft.; draught, 8 ft. 6 in. With a pressure of 120 lbs. per square inch in the four boilers, the engines are calculated to give out 3,000 horse-power, so as to achieve a speed of 18 knots an hour, or half a knot more than that stipulated for.

MEETINGS FOR THE ENSUING WEEK.

Monday, June 21...Colonial and Indian Exhibition, South Kensington, S.W., 4 p.m. Mr. W. Senior, "The Colony of Queensland."
British Architects, 9, Conduit-street, W., 8 p.m.
Asiatic, 22, Albemarle-street, W., 4 p.m.

Tuesday, June 22...Colonial and Indian Exhibition, South Kensington, S.W., 4 p.m. Conference of the Anthropological Institute. "Races of Australia."
Statistical, School of Mines, Jermyn-street, S.W., 7¾ p m. The Hon. Sir Robert Stout, "Notes on the Progress of New Zealand for Twenty Years, 1864-1884."
Anthropological, 3, Hanover-square, W., 8 p.m.
Horticultural, South Kensington, S.W., 1 p.m. Show of Pelargoniums, &c.

Wednesday, June 23...Colonial and Indian Exhibition, South Kensington, S.W , 4 p.m. Mr. W. Lant Carpenter, "The Position of Science in Colonial Education."
Geological, Burlington-house, W., 8 p.m. Papers by Prof. T. McKenny Hughes, Dr. Charles Callaway, Mr. A. Strahan, Mr. Edwin Gilpin, Mr. H. M. Becher, Mr. W. Hamilton Merritt, Mr. R. Lydekker, Mr. W. Whitaker, Dr. A. B. Griffiths, and Mr. James Carter.
Royal Society of Literature, 4, St. Martin's-place, W.C., 8 p.m.

Thursday, June 24...Colonial and Indian Exhibition, South Kensington, S.W., 11 a.m. Conference of the Central Emigration Society. "Emigration from Colonial Point of View." 3 p m. "The Best Method of Colonisation." 8 p.m. Mr. T. Wardle, "The Indian Silks in the Exhibition."
Antiquaries, Burlington-house, W., 8½ p.m.
Society for the Encouragement of Fine Arts, 9, Conduit-street, W., 8 p.m. Mr. T. H. Maguire, "The Importance of the Fine Arts to Humanity."

Friday, June 25...Colonial and Indian Exhibition, South Kensington, S.W., 11 a m. Conference of the Central Emigration Society. "The Duty of the Church towards Emigration." 3 p m. "Emigration of Children." 8½ p.m. Mr. F. W. Pennefather, "Natives of New Zealand," with Limelight Illustrations.
United Service Institute, Whitehall-yard, S.W., 3 p.m. Captain J. C. R. Colomb, "Imperial Federation, Naval and Military."
Quekett Microscopical Club, University College, W.C., 8 p.m.
Browning, University College, W.C., 8 p.m. Annual Meeting, Election of Officers, &c. Paper by Mr. C. H. Herford.

Saturday, June 26...Colonial and Indian Exhibition, South Kensington, S.W., 4 p.m. Dr. H. Trimen, "The Vegetation of Ceylon."
Physical Science Schools, South Kensington, S.W., 3 p.m. Mr. Herbert Tomlinson, "Certain sources of error in connection with experiments on Torsional Vibration."
Botanic, Inner Circle, Regent's-park, N.W., 3¾ p.m.

Journal of the Society of Arts.

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FRIDAY, JUNE 25, 1886.

All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

NOTICES.

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FINANCIAL STATEMENT.

The following statement is published in this week's *Journal*, in accordance with sec. 40 of the Society's Bye-laws :—

TREASURERS' STATEMENT OF RECEIPTS, PAYMENTS, AND EXPENDITURE FOR THE YEAR ENDING MAY 31ST, 1886.

Dr.

	£	s.	d.	£	s.	d.
To Cash in hands of Messrs. Coutts and Co., 31st May, 1885	827	6	5			
Do. in hands of Secretary	22	5	1			
				849	11	6
,, Subscriptions received during the year from Members and Institutions in Union	6,500	6	0			
,, Life Compositions	451	10	0			
				6,951	16	0
,, Transferred from Deposit with Messrs. Coutts and Co. on account of "Westgarth" Prizes				1,200	0	0
,, Dividends and Interest				661	18	11
,, Ground Rents				171	10	0
,, Examination Fees				216	10	0
,, House and Office (receipts for gas, &c.)				45	3	0
,, Advertisements				1,605	7	10
,, Sales—						
Cantor Lectures	16	2	7			
Conversazione Tickets	1,549	17	6			
Examination Papers	2	17	7			
Japanese Exhibition Catalogues	3	12	0			
Journal	173	7	7			
Public Health Conference Reports		5	6			
Spoiled Post-cards	1	15	5			
Transactions		10	0			
				1,748	8	2
				£13,450	5	5

Cr.

	£	s.	d.	£	s.	d.
By House and Premises :—						
Rent, Rates, and Taxes	356	10	4			
Insurance, Gas, Coal, House expenses, and charges incidental to ordinary meetings	278	8	1			
Repairs and Alterations	68	2	1			
				703	0	6
,, Office:—						
Salaries and Wages	2,085	14	7			
Stationery, Office Printing, and Lithography	323	15	4			
Advertising	55	10	6			
Postage Stamps, Messengers' Fares, and Parcels	182	8	4			
				2,647	8	9
,, Library, Bookbinding, &c.				92	12	11
,, Conversazione				1,849	17	3
,, *Journal*, including Printing, Stamps, and Distribution				2,627	15	1
,, Advertisements (Agents and Printing)				717	17	3
,, Examinations				322	9	9
,, Memorial Tablets				7	5	6
,, Medals :—						
Albert	22	8	6			
Society's	19	11	6			
				42	0	0
,, Prizes (awards and expenses) :—						
Davis	120	0	0			
Fothergill	20	0	0			
Howard	104	9	4			
Owen Jones	28	17	9			
Westgarth	1,225	0	0			
				1,498	7	1
,, Cantor Lectures				326	12	6
,, Lectures on Electricity				61	16	0
,, Juvenile Lectures				21	1	5
,, Sections :—						
Applied Chemistry and Physics	51	4	0			
Foreign and Colonial	61	4	0			
Indian	74	0	0			
				186	8	0
,, Japanese Exhibition				15	10	4
,, Committees :—						
Musical Pitch	14	14	3			
General expenses	14	17	3			
				29	11	6
,, Donation to repair of York Water Gate				10	0	0
,, Annuity to Mrs. Le Neve Foster				25	0	0
,, Investment in Reduced 3 per Cent. Stock of Life Compositions of the year	451	10	0			
,, Do. in Queensland Bonds from income of the year 509 7 6						
,, Do. in Canada 4 per Cent. Stock 523 15 0						
	1,033	2	6			
				1,484	12	6
				12,669	6	4
,, Cash in hands of Messrs. Coutts and Co., May 31st, 1886	754	0	9			
,, Do. in hands of Secretary	26	18	4			
				780	19	1
				£13,450	5	5

LIABILITIES.

	£	s.	d.	£	s.	d.
To Tradesmen's Bills	461	1	1			
,, Rates	47	18	4			
,, Examiners' Fees	117	11	0			
,, Sections:—Foreign and Colonial, Applied Chemistry, and Indian	190	0	0			
,, Accumulations under Trusts	200	15	1			
,, Balance of Money received from Union Centrale des Arts Décoratifs, Paris	20	7	0			
				1,037	12	6
Excess of Assets over Liabilities				13,092	18	5
				£14,130	10	11

ASSETS.

	£	s.	d.	£	s.	d.
By Society's Funds invested in—						
Reduced 3 per Cent. Stock, £7,168 15s. 4d., worth, on 31st May, 1886, £7,231 9s. 11d., less £757 15s. 11d., reserved to meet Trusts No. 6, 7, and 8 below	6,473	14	0			
£217 Great Indian Peninsula Railway 4 per Cent Debenture Stock, worth on 31st May, 1886	233	16	4			
£1,500 Queensland 4 per Cent. Bonds, worth on 31st May 1886	1,550	12	6			
£500 Canada 4 per Cent. Stock, worth on the 31st May, 1886	527	10	0			
				8,785	12	10
,, Subscriptions of the year uncollected	732	18	0			
,, Arrears, estimated as recoverable	250	0	0			
				982	18	0
,, Property of the Society, including Barry's Pictures and Lease of House				2,000	0	0
,, Advertisements on the Books, due and in course of execution*				1,381	1	0
,, Cash in hands of Messrs. Coutts and Co., 31st May, 1886				754	0	9
,, Ditto on Deposit				200	0	0
,, Ditto in hands of Secretary				26	18	4
				£14,130	10	11

* A portion of this sum is liable to charges for printing.

INVESTMENTS STANDING IN THE NAME OF THE SOCIETY.

	£	s.	d.
Ground Rents on Tyssen-Amherst Estate	£4,590	0	0
Consols	425	8	9
New 3 per Cents	388	1	4
Reduced 3 per Cents	7,168	15	4
Metropolitan Railway 4 per Cent. Perpetual Preference Stock	500	0	0
Oude and Rohilcund Railway 5 per Cent. Guaranteed Stock	2,150	0	0
Bombay and Baroda do. do.	2,450	0	0
Canada 4 per Cents	923	0	0
India 4 per Cents	105	18	7
Great Indian Peninsula Railway 4 per Cent. Guaranteed Debenture Stock	2,170	0	0
Queensland 4 per Cent. Bonds	1,500	0	0
Cash on deposit with Messrs. Coutts and Co.	200	0	0

TRUST FUNDS INCLUDED IN THE ABOVE.

		£	s.	d.	
1.	Dr. Swiney's Bequest	£4,500	0	0	Invested in ground-rents, and chargeable with a sum of £200 once in five years.
2.	John Stock Trust	100	0	0	Consols, chargeable with the Award of a Medal.
3.	Benjamin Shaw Trust for Industrial Hygiene Prize	133	6	8	,, ,, ,, Interest as a Money Prize.
4.	North London Exhibition Trust	192	2	1	,, ,, ,, ,, ,,
5.	Fothergill Trust	388	1	4	New 3 per Cents. chargeable with the Award of a Medal.
6.	J. Murray, in aid of a Building Fund	54	18	0	Reduced 3 per Cent. Stock.
7.	Subscription to an Endowment Fund	562	2	2	
8.	Dr. Aldred's Bequest	140	15	9	
9.	Thomas Howard's Bequest	500	0	0	Metropolitan Railway 4 per Cent. Perpetual Preference Stock.
10.	Dr. Cantor's Bequest	4,600	0	0	Bombay and Baroda and Oude and Rohilcund Railway 5 per Cent. Guaranteed Stock.
11.	Owen Jones Memorial Trust	423	0	0	Canada 4 per Cent. Stock, charged with the Award of Prizes to Art Students.
12.	Mulready Trust	105	18	6	India 4 per Cent Stock, the Interest to be applied to keeping Monument in repair and occasional Prizes to Art Students.
13.	Alfred Davis Bequest	1,953	0	0	Great Indian Peninsula Railway 4 per Cent. Guaranteed Debenture Stock.
14.	Accumulated Interest on Trust Funds	200	0	0	On Deposit with Messrs. Coutts and Co.

The Receipts of the Society set forth above have been credited by Messrs. Coutts and Co.

Payments set forth above have been made by authority of the Council.

The Assets, represented by Stock at the Bank of England, and securities, cash on deposit, and cash balance in hands of Messrs. Coutts and Co., as above set forth, have been duly verified.

W. R. MALCOLM,
B. FRANCIS COBB, } *Treasurers.*

H. TRUEMAN WOOD, *Secretary.*

ANDREW D. CHADWICK, *Auditor, pro. tem.*

Society's House, Adelphi, 8th June, 1886.

ANNUAL GENERAL MEETING.

The Council hereby give notice that the One Hundred and Thirty-second Annual General Meeting, for the purpose of receiving the Council's Report and the Treasurer's statement of receipts, payments, and expenditure during the past year, and also for the election of officers and new members, will be held, in accordance with the Bye-laws, on Wednesday, the 30th June, at 4 p.m.

(By order of the Council)
H. TRUEMAN WOOD,
Secretary.

CONVERSAZIONE.

The Society of Arts Conversazione will be held, by permission of the Royal Commission, at the Colonial and Indian Exhibition, South Kensington, on Friday, the 16th of July next.

Each member will receive a card for himself, which will not be transferable, and a card for a lady. In addition to this, cards will be sold to members of the Society, or to persons introduced by a member, at the following prices :—Until the 3rd of July, 7s. each ; after that date 10s. each, except on the 16th July, when the price will be 15s.

The Council, however, reserve the right of stopping the sale of tickets or of raising the price, if it is found necessary, in order to restrict the number of visitros within reasonable limits.

Tickets will only be supplied to persons presenting members' vouchers (forms of which can be obtained from the Secretary), or a letter of introduction from a member.

Members can purchase these additional tickets by personal application, or by letter addressed to the Secretary. In all cases of application by letter, a remittance must be enclosed. Each ticket will admit one person, either lady or gentleman.

Light refreshments (tea, coffee, ices, &c.) will be supplied at the usual buffets. No refreshments can be obtained by purchase. It will greatly facilitate the arrangements if members requiring additional tickets will apply for them at as early a date as convenient. The members' invitations have been issued. Visitors' tickets can be purchased from the present date.

There will be no admission to the Exhibition on this evening except by special ticket, and no tickets can be purchased at the Exhibition.

Further particulars as to the arrangements will be announced in future numbers of the *Journal.*

Proceedings of the Society.

CANTOR LECTURES.

PETROLEUM AND ITS PRODUCTS.

By BOVERTON REDWOOD, F.I.C., F.C.S.

[The right of reproducing these lectures is reserved.]

Lecture II.—Delivered March 15th, 1886.

I have already stated that although the rapid development of the petroleum industry in the United States dates from the sinking of the Drake well in 1859, the credit of devising the method of drilling then adopted does not belong to Mr. Drake, since wells had previously been drilled for brine in a similar manner. In order to form an intelligent conception of the improvements which have been effected since 1859, it will be necessary to examine somewhat in detail the arrangements which Mr. Drake and his predecessors employed, but before proceeding to do this we must first consider certain more primitive methods of obtaining the crude oil.

Professor Silliman's description of the process of obtaining the crude petroleum from the oil spring of the Seneca Indians near Cuba, New York, by skimming it off the surface of the water by means of boards, was given in the previous lecture, and this may fairly be taken as indicative of the manner in which the petroleum was first collected. Occasionally the pool of oil-covered water was surrounded by a stone coping to increase its depth, and woollen cloths were sometimes used to absorb the oil.

There is, however, ample evidence in various countries that, from a very remote period, pits and wells have been dug for the purpose of obtaining the oil. The reference by Herodotus to the use of half a wine-skin for drawing up petroleum from such a well at Arderrica has already been noticed, and in China the digging of wells, from which petroleum and brine are collected, is an operation of great antiquity. In Japan, in Burmah, and in other countries, petroleum wells are still excavated by hand. A great deal of interesting information, in reference to the operation of petroleum well-sinking in Japan, is given in Mr. Lyman's reports, to which I have already had occasion to refer. In these reports, it is stated that the excavating is done by two men, one of whom digs in the morning from nine o'clock until noon, and the other from noon until three. The one who is not digging works a large blowing machine that sends fresh air to the bottom of the well. The blowing apparatus is a wooden box about 6 feet long by 3 feet wide and 2 feet deep, with a board of the same length and width, turning in it upon a horizontal axis at the middle of each side of the box, and with a vertical division below the board between the two ends of the box. The workman stands upon the board, and walks from one end of it to the other, alternately depressing the ends. At his first step on each end he gives a smart blow with his foot, so as to close with a jerk a small valve (0·3 foot square) beneath the end of the board, the valve opening by its own weight when the end of the board rises. The air is therefore driven first from one end of the box, then from the other, into an air pipe about 0·8 foot square, provided at the top with a small valve for each end of the blowing-box. The air pipe is made of boards in lengths of about 6 feet, and is placed in one corner of the well. The well is, besides, timbered with larger pieces at the corners, and light cross pieces, which serve also as a ladder for going up and down, though at such a time, in addition, a rope is tied round the body, under the arms, and held by several men above the mouth of the well. The earth or rock excavated is brought out of the well in rope nets, by means of a rope that passes over a wheel 1 foot in diameter, hung just under the roof of a hut which covers the mouth of the well. The rope nets are drawn up by three men, one at each corner of one side of the well, and the third in a hole two or three feet deep, and a foot and a half wide, dug along the side of the well. I have on the table a photograph of a Japanese oil-district, showing the huts or well coverings alluded to. This photograph was given me by a friend who recently visited the petroleum fields of Japan. The wells are about 3½ feet square, and are dug in the manner described to the remarkable depth of 600 to 900 feet. At this depth there is great difficulty in securing sufficient light to carry on the work, and it is frequently necessary for this reason to suspend work at three o'clock. The oil is skimmed from the surface of the water, and drawn up in buckets. Mr. Lyman is of opinion that it would be the reverse of advantageous to introduce the system of drilling with steam power in Japan, on account of the cost of the necessary machinery, the heavy expense of fuel in the locality, and the difficulty of transporting machinery in a country almost wholly without waggon roads. The cost of a well in Echigo, 900 feet in depth, is stated to have been only £200, which is little more than a third of the expense of drilling to that depth in England or America. Moreover, a dug well can be entered for cleaning or repairing, while a drilled well obviously cannot; besides which, the former description of well necessarily exposes a larger surface for the oil to percolate through, and is also frequently furnished with horizontal galleries extending from the bottom, which largely add to the extent of surface of oil rock exposed. There are, however, as Mr. Lyman points out, some improvements which might advantageously be introduced into the present system. Thus, at present, the only light obtained is that which is reflected from a piece of yellowish translucent oil paper, about 5 feet long by 3½ feet wide, suspended over the well at an angle of 45 degrees with the horizon, across an opening in the roof of the grass hut that covers the well; and it would be easy to substitute for this primitive reflector a common mirror. A small mirror could also be used at the bottom of the well to reflect light into the galleries, which at present are so dark that they cannot be excavated to a greater length than about a dozen feet. A flame cannot be used in the well as a source of light on account of the presence of inflammable gas, but the incandescent electric light, if not too costly, might be employed, and the working hours thus extended. A better system of ventilation might also be adopted; and the use of pumps for raising the water and oil, as well as of a water-tight well-casing, which might be made of timber, to prevent the influx of water, would also facilitate the collection of the petroleum. The small yield of the wells, however, would preclude the employment of any expensive appliances, the total yield of the wells in the oil-fields of Echigo and Shinano, being only, according to Mr. Lyman, between 11,000 and 12,000 barrels per annum.

As an illustration of the cheapness of the present system, I quote the following particulars given by Mr. Lyman, on the authority of Mr. Kada:—

4 posts	$0.100
1 board (6 ft. by about 1 ft.)	0.120
12 cross-pieces, $0·96 to $0·216	0·156
Materials for one length (4 ft.) of timbering	0·376
Materials for hut—wood, $1; rushes, $0·63	1·630
1 pair of bellows	3·750
1 length of air-pipe (6 ft.)	0·140
1 wheel (two needed for one well)	1·200
1 tank (6 ft. diameter, 6 ft. high)	15·000
1 well bucket	0·500
6 ft. straw rope	0·012
10 soka (? 5,000 feet) small straw rope	0·475
1 pick (large one 16⅔ lbs., small one 6⅔ lbs.)	?
1 rake	0·500
3 rope nets	0·350
1 oil paper	0·320
1 pot for boiling the labourers' rice or water	0·620

In the locality where these prices prevailed, in 1868, the wages of the diggers, not including food, were $0·18¾ per man per day, and of the common labourers $0·10. One shoo of rice beer (saké) value $0·065 had, however, to be provided for every four men. The number of workmen needed was, according to the depth of the well, as follows:—

From 1 to 10 fathoms	3 men.
„ 10 „ 30 „	4 „
„ 30 „ 40 „	5 „
„ 40 „ 50 „	6 „

In the locality in question the depth of the wells rarely exceeded 50 fathoms.

I have already referred in some detail to the oil district of Yenangyoung, in Burmah. According to the Rev. J. M. Cushing, the wells here are dug in the most primitive manner, a native spade for loosening the soil, and a basket for removing it from the well, being the only implements used. The wells are about 60 feet in depth, and 5 feet square, and are planked with split timber. There are generally three or four men employed in the work of digging, each one taking his turn, and, while working in the well, having a rope fastened round him. Sometimes there is so much gas present that the digger cannot remain in the well more than a couple of minutes, and occasionally a man is drawn up quite insensible. The usual time of remaining down is about twenty minutes, and the digger jerks the rope when he wishes to be drawn up. The oil is raised in a bucket attached to one end of a rope running over a wheel fixed above the mouth of the well. The other end of the rope is fastened to the waist of a man or woman, who generally has two or more boys or girls to assist in pulling. As soon as the bucket fills, these persons run down a beaten path, and the bucket is thus drawn to the mouth of the well, when it is emptied by another person.

In Wallachia, and also in Galicia, dug wells exist, and in Moldavia there are dug wells more than 130 feet deep, lined with woven sticks.

The most perfectly constructed dug wells are those which exist in Italy. Professor Stoppani, of Milan, describes the petroleum wells at Montechino, Piacenza, which may be taken as a type of the Italian wells, as perfectly cylindrical in form, and lined with large bricks firmly cemented together. Some of these wells are as much as 240 feet in depth, and eight feet to ten feet in diameter. The Montechino wells are stated to yield from 160 to 180 lbs. of oil each per day. The oil, which is drawn up in buckets, is of very remarkable character. I have a sample of it on the table, and you will note that it possesses but little more colour than ordinary refined oil has. It is, in fact, so pure that it can be burned in its crude state in suitable lamps, though in consequence of the presence of a large quantity of the more volatile hydrocarbons it is very inflammable, at once taking fire upon the application of a flame. These wells cannot be dug deeper in consequence of the presence of petroleum gas and vapour, several lives having been lost in attempts to deepen them. The collection of oil from the wells at Montechino has been going on for eighty years.

Having thus considered methods of well construction, and petroleum collection, which are comparatively simple, but, as we have seen, suited to the requirements of the countries wherein they are adopted, we now take up the subject of the development of artesian drilling for petroleum, as practised in the United States and elsewhere.

The art of artesian well drilling in China is doubtless one of considerable antiquity, wells in that country being successfully bored to great depths with the object of obtaining brine. L'Abbé Huc gives the following interesting description of the process adopted:—

"If there be a depth of three or four feet of soil on the surface, they plant in this a tube of hollow wood, surmounted with a stone, in which an orifice of the desired size of three or four inches has been cut. Upon this they bring to work in the tube a rammer of 300 lbs. or 400 lbs. weight, which is notched, and made a little concave above and convex below. A strong man, very lightly dressed, then mounts on a scaffolding, and dances all the morning on a kind of lever that raises this rammer about two feet, and then lets it fall by its own weight. From time to time a few pails of water are thrown into the hole to soften the rock and reduce it to pulp. The rammer is suspended to a rattan cord, not thicker than your finger, but as strong as our ropes of catgut. This cord is fixed to the lever, and a triangular piece of wood is attached to it, by which another man, sitting near, gives it a half turn so as to make the rammer fall in another direction. At noon this man mounts on the scaffold and relieves his comrade till the evening, and at night these two are replaced by another pair of workmen. When they have bored three inches they draw up the tube, with all the matter it is loaded with, by means of a great cylinder which serves to roll the cord on. In this manner these little wells or tubes are made quite perpendicular [to a depth of from 1,500 to 1,800 feet French], and as polished as glass. When the rock is good the work advances at the rate of two feet in twenty-four hours, so that about three years are required to dig a well."

Artesian-well drilling was first practised in Europe, in the province of Artois, in France, where a drilled well exists in the gardens of a former Dominican convent at Lillers, which is stated to have flowed continuously since the year 1126.

In the United States the first artesian well was drilled in 1806, with the object of obtaining brine, by the brothers Ruffner. These operators first attempted to keep out the surface water, and reach the undiluted brine by sinking in the mire and quicksand, through which the salt water flowed, a straight, well-formed hollow sycamore tree, four feet in internal diameter. After much labour, the lower end of the trunk reached a hard crust, which they took to be solid rock, at a depth of thirteen feet, but in consequence of the impossibility of keeping out the fresh water, the attempt was abandoned. They then commenced another well at a little distance, using a 3½-in. tube, made by boring lengthwise through a 20-ft. oak log, but, again failing, they returned to the first well, and finally succeeded in sinking the "gum," as the hollow tree was termed, through the crust mentioned, to a depth of sixteen or seventeen feet, when solid rock was reached. Much difficulty was then experienced in making a watertight connection between the lower end of the "gum" and the rock, but this was finally accomplished by using wooden wedges, The brothers then commenced drilling the rock with a long iron drill suspended from a "spring pole," and with a 2½-in. chisel-bit of steel. Eventually, in 1808, after much tedious labour, they completed a hole in the rock of forty feet in depth, or fifty-eight feet from the upper end of the "gum," and obtained a plentiful supply of brine. It was, however, found necessary to devise some means of preventing the dilution of the brine by the infiltration of fresh water through the upper part of the well, and they accordingly set to work to manufacture two half tubes out of strips of wood, joining the edges carefully, and binding the halves together with twine. This tube, with a bag of wrapping at the lower end made to fit as nearly as possible water-tight in the 2½-in. hole, was then driven into the well, and was found to answer its purpose perfectly, the brine flowing up into the "gum," where a water-tight bottom was constructed to retain it.

Other improvements followed. Tin tubes, and afterwards copper tubes with screw-joints, were substituted for the wooden tubing, but the most important step was the adoption of the arrangement called a "seed-bag" to form the water-tight joint at the lower end of the tube. This "seed-bag" consisted of a piece of buckskin or calfskin, sewed up like the sleeve of a coat, so as to form a tube about 12 or 15 inches in length, and about the diameter of the well. This was slipped over the well tubing, and the lower end having been securely bound to the tube, was filled to the depth of 6 or 8 inches with flax seed, either alone or mixed with gum tragacanth. The upper end having then, like the lower, been bound to the tubing, but not securely, so that the bag would empty itself if it was needful to draw up the casing, the arrangement was lowered into the well to the required depth, and the contents of the seed-bag soon swelling by the absorption of water, a tight joint was made.

In describing the drilling tools now used, I shall have to refer to an instrument termed "the jars." This was invented by William Morris, in 1831, and consists of a long double link, arranged to slide loosely. The function of the jars, as now employed in drilling, is to give the drilling tools a sharp jar, thus preventing the bit from getting jammed in the rock, or loosening it if it has become so.

The spring pole referred to as having been employed by the brothers Ruffner continued for some time to be largely used in hand drilling, and should therefore be described. It consisted of a straight tree, 40 feet or 50 feet in length, denuded of its branches, and fixed in the ground at an angle of about 30° over the spot where the well was to be drilled. From the upper and smaller end of the tree the drilling tools were suspended, and the required movement was imparted by pulling down the end of the pole and then allowing it to spring back. The spring pole is, however, no longer employed in drilling petroleum wells in the United States, and steam-power is invariably made use of.

Steam - power and horse-power were also employed in drilling for brine, prior to the sinking of the Drake well.

The first operation in the sinking of a petroleum well in America is the erection of what is termed a derrick, a perfect model of which, constructed for me in the United States, is before you. The derrick is, as you see, a timber structure, pyramidal in form, and consisting, in the main, of four uprights, held in position by the necessary ties and diagonal braces. At the present time the derrick is usually about 70 feet in height, and 20 feet square at the base, and costs about $500.

The height of the derrick has necessarily been increased *pari passu* with the depth of the wells and length of the tools, but at the present time, in the Franklin and other districts, where the wells are shallow, derricks not more than 30 feet in height are still employed. The earlier form of derrick is shown in the photograph of the historic Drake well. The lower part is usually boarded up when drilling is being done in winter, in order to protect the workmen from the inclemency of the weather. Immediately outside the derrick stands the "Sampson post," a massive pillar of wood which supports the "walking beam." Inside the derrick stands a smaller upright termed the "headache post" or "life preserver," designed, as its name implies, to save the driller from being struck on the head by the end of the walking-beam in the event of the connection breaking. The end of the walking - beam outside the derrick is connected by means of a rod termed the "pitman," with a crank attached to the axle of what is known as the "band-wheel." This band-wheel runs in bearings on a couple of uprights, and is caused to revolve through the medium of a band driven by a steam-engine in an adjoining shed, a rocking movement being thus imparted to the walking-beam. The steam-engine is now usually of 12 to 15 horse-power, and steam is generated in a boiler of the locomotive type, fired with natural gas. To the opposite side of the derrick are fixed the bearings of the "bull-wheel," a windlass of solid construction, used for lowering and raising the drilling tools, the supporting cable passing over a grooved wheel, termed the "crown pulley," at the top of the derrick, and being coiled on the drum or axle of the bull-wheel. Between the band-wheel and the bull-wheel the "bull-rope," made of two inch plain-laid cable, joined by iron couplings, passes. This rope runs in a groove in both wheels, and imparts motion to the windlass. The latter is provided with a powerful brake. A second windlass, termed a "sand-reel," is also provided. This smaller windlass, which is used for raising the detritus from the well, is fixed near the band-wheel, and can be brought into contact with the face of the band-reel, by pulling a lever inside the derrick, and the driller can thus from the mouth of the well start or stop the revolutions of the sand-reel. An endless cord, termed "the telegraph," passes round a pulley on the throttle-valve of the engine steam-pipe and a similar pulley in the derrick, so that the driller can also start or stop the engine. The reversing link is also operated by a cord from the derrick. The bull-wheel being, as explained, driven through the medium of the band-wheel, it is necessary to disconnect the pitman when the bull-wheel is used, and to throw the rope off the bull-wheel when the walking-beam is to be set in motion. The cable used to support the drilling tools is a 6-in. (2 inches in diameter) untarred Manilla rope. Wire rope is not used, as it is not sufficiently pliable to admit of its being coiled on the shaft of the bull-wheel.

The illustrated descriptive catalogue issued by the Oil Well Supply Company, of Bradford and Oil City, Pa., in 1884, a copy of which was given me by the president of the company, Mr. John Eaton, when I was in Bradford last year, contains instructive particulars of the tools now employed in drilling. From that publication I take the following particulars of the length and weight of a string of tools :—

	Length.		Weight.
	ft.	in.	lbs.
Rope socket ……	3	0	90
Sinker bar ……	12	0	400
Jars ……	6	0	300
Auger stem ……	32	0	1,050
Bit ……	3	4	140
	56	4	1,980

Mr. Carll, writing at an earlier date, gives the length of the string of tools as 62 ft 1 in., and the total weight as 2,100 lbs., the chief difference being in the length and weight of the sinker-bar. I have on the table a miniature set of drilling tools, made to scale, which Mr. Wm. M. Irish, of Olean, New York, has kindly supplied me with.

In addition to the tools enumerated, the following are required to complete the set:—Temper-screw, large jars, large bits, reamers, and two wrenches.

The tools are made of the best steel and Norway iron. The cost of the complete set of drilling tools is stated by Mr. Carll, whose detailed report has supplied me with much valuable information on the subject of drilling, to be $692, the driller's complete outfit costing about $900. To complete the outfit, a "sand-pump," or bailer, to remove the detritus from the well, is required. This apparatus often consists simply of a plain cylinder of thin galvanised iron, usually about 6 feet in length, but sometimes as long as 15 or 20 feet, provided at the bottom with a valve opening inwards. The valve is provided with a stem projecting downwards, so that, when the filled cylinder is lowered into a trough, the valve is pushed open, and the contents of the cylinder discharged. A better form of sand-pump consists of a wrought-iron cylinder, having, in addition to the bottom valve, a plunger attached to an iron rod passing through a stirrup spanning the top of the cylinder. The sand-pump is, in the latter form, suspended from the end of the plunger rod, and when it reaches the bottom of the well, the slackening of the rope allows the plunger to descend to the bottom of the cylinder; on tightening the cord, the plunger is first raised, and the entrance of the detritus into the cylinder is facilitated; when the plunger has reached the stirrup, the cylinder itself begins to rise, and the valve closes. The rope attached to the sand-pump passes over a small pulley at the top of the derrick, to the sand-reel already described. Besides the drilling tools referred to, a large number of so-called "fishing tools" are employed, when, through breakage of the cable or otherwise, the tools, or any of them, remain in the well.

The first step in the drilling of a well is to sink a "conductor" through the surface ground to the "bed-rock." When the superficial clays and gravels are not more than 10 or 15 feet in thickness, a common well shaft, 8 or 10 feet square, is dug to the surface of the rock. A wooden conductor, 8 inches square in the clear, is then set up perpendicularly between the rock and the boarded floor of the derrick, the junction between the rock and the conductor being so made as to keep out gravel and mud. When the depth of surface ground is too great to admit of digging down to the rock, iron piping, termed "driving-pipe," is driven in by means of a "mall," working in guides, as in pile-driving. When two or three hundred feet have to be thus driven, as is sometimes the case, a good deal of skill is required. When the conductor is sunk to the bed-rock, the operation of drilling is commenced, but before proceeding to describe this operation I must direct your attention to the tools, and point out their uses. The composition of the string of tools has already been stated. The jars practically divide the string into two parts, the one delivering its blow downwards and the other upwards. The auger or drill which cuts and pulverises the rock consists of the bit, the auger-stem and the lower link of the jars, while the function of the sinker bar and upper link of the jars is to deliver a blow on the upward stroke, so that the *jar* may loosen the drill in case it should have become jammed in the rock. I have already referred to the invention of the jars. This appliance, which is of the greatest value, may be likened to two flat links of a chain, the cross-head of the upper one passing through the slot of the lower. The length of the slots is such that there is a play of nine inches, though a longer play has sometimes been given. Some writers are apparently under the impression that the sinker bar is used to drive the bit into the rock, but this is not the case, a skilful driller never allowing the jars to strike together on the downward stroke. The various members of the string of tools are connected by male and female screws. The "temper screw," inserted between the walking-beam and the cable, admits of letting out the latter gradually, as the drill enters the rock. The "rope-socket" firmly grasps the cable at the required point, and from it the tools are suspended to the end of the walking-beam.

We now take up the consideration of the operation of drilling. If the bed-rock is reached at a less distance than about sixty feet from the surface, the drilling tools cannot at first be used in the ordinary manner. Under these circumstances the drilling of the rock is commenced by the operation termed "spudding," which consists in alternately raising and dropping the tools by tightening and then slackening the cable, which for this purpose is simply coiled two or three times round the revolving bull-wheel. A sufficient depth having been reached to admit of the regular use of the drilling tools, the cable is properly coiled on the bull-wheel shaft, the bull-rope is thrown off, the pitman connected, and the string of tools lowered into the well by releasing the bull-wheel brake, and suspended from the walking beam. The tools having run to the bottom of the well, and the jars having closed by the slackening of the cable, the slack is taken up by turning the bull-wheel by hand until the cross-heads of the jars come together, this being plainly indicated by a tremulous motion imparted to the cable. About four inches of cable being then paid out, the tools are in the right position, and the walking-beam is started. If the vertical motion be 24 inches, the sinker bar first moves 4 inches on the up-stroke; the cross-heads of the jars then come together with a sharp blow, and the auger stem is lifted 20 inches. On the down-stroke the auger stem falls 20 inches, and delivers its blow on the rock, while the sinker bar goes down 24 inches to telescope the jars. An unskilled workman sometimes closes the jars (especially if the well be deep and nearly full of water), and works for hours without accomplishing anything, as the tools may be resting on the bottom or remaining suspended, but an expert can tell, by placing his hand on the cable, whether the drill is working properly or not. Before the well reaches a great depth, the movement of the tools can be distinctly recognised by grasping the cable, as I have myself found. As the jar grows feeble, it is "tempered" to the proper strength by slightly altering the position of the temper screw, and thus letting out a little more cable. The best drillers now, however, often drill by the spring of the cable, only using the jars when the bit sticks. Under these circumstances, the tools are suspended so that the bottom of the bit is from 5 inches to 3 feet from the bottom of the hole, the distance depending on the length and consequent spring of the cable. The walking beam being set in motion, the tools rise and fall, and the elasticity of the cable allows them to touch the bottom and bound from it. This operation is termed "bouncing the drill," and the rock is thus cut faster than by the old method. As the drilling proceeds, the driller slowly rotates the temper-screw so as to cause the chisel end of the bit to do its work evenly. When the whole length of the temper-screw has been unscrewed, or the bit requires sharpening, the bull-rope is placed on the bull-wheel, and the string of tools drawn up. The sand-pump is then lowered into the well, some water being first thrown down if necessary, and the pulverised rock thus removed. Drilling and sand pumping thus proceed alternately day and night, unless a break-down occurs, one driller and one engineer working from noon till midnight, and another pair from midnight till noon. At night the derrick is lighted with a primitive form of lamp, which, as you see, is something like an iron kettle with a spout on each side, in which crude petroleum is burned. The operation of drilling seldom, however, proceeds very long without the aid of the "fishing tools" being required. Perhaps the cable breaks, or one of the tools becomes detached, and the operation of extraction, which is termed "fishing," is often very tedious. Considerable skill has, however, been expended in devising tools to meet almost all conceivable cases, and there are now, as Mr. Peckham says, hundreds if not thousands of tools available; from the delicate "grab" designed to pick up a small piece of valve-leather, to the ponderous string of "pole tools" containing tons of iron, by means of which a set of tools can be unscrewed at a depth of 1,500 feet, and brought up one by one, or a thread can be cut on the broken end of a sinker bar or auger stem. The time occupied in drilling to the depth of about 1,700 feet, and the extent of the delays which may arise from accidents, are shown in the following record relating to a well in the Bradford field:—

DENNIS WELL, No. 1.

Situated on Roger's farm, ¾ miles S., 25° W. of Bradford, McKean Co, Pa.

1877.		Daily advance. feet.		Depth. feet.
Nov. 29.	Conductor—21 ft. previously set	12	to	33
,, 30.	Thawing supply pipes	—		—
Dec. 1.	Pulling tubing from water well	—		—
,, 2.	(Sunday)	—		—
,, 3.	....	34	,,	67
,, 4.	....	48	,,	115
,, 5.	....	60	,,	175
,, 6.	....	35	,,	210
,, 7.	....	50	,,	260
,, 8.	Engine gives out	31	,,	291
,, 9.	(Sunday)	50	,,	341
,, 10.	....	49	,,	390
,, 11.	....	45	,,	435
,, 12.	Putting in casing	10	,,	445
,, 13.	....	101	,,	546

1877.		Feet.		Feet.
Dec. 14.		86	to	632
,, 15.		66	,,	698
,, 16.	(Sunday)	—		—
,, 17.		72	,,	770
,, 18.		68	,,	838
,, 19.		81	,,	919
,, 20.		34	,,	953
,, 21.		34	,,	987
,, 22.		34	,,	1,021
,, 23.	(Sunday)	—		—
,, 24.	Broke jars and lost tools at 1,056 feet	35	,,	1,056
,, 25.	(Christmas)	—		—
,, 26.	Fishing	—		—
,, 27.	Fishing	—		—
,, 28.	Fishing; got tools out minus bit	—		—
,, 29.	Fishing	—		—
,, 30.	(Sunday)	—		—
,, 31.	Fishing	—		—
1878				
Jan. 1.	Fishing; pin broke above jars	—		—
,, 2.	Fishing	—		—
,, 3.	Cleared the hole	7	,,	1,063
,, 4.		7	,,	1,070
,, 5.		15	,,	1,085
,, 6.	(Sunday)	—		—
,, 7.		15	,,	1,100
,, 8.		16	,,	1,116
,, 9.		9	,,	1,125
,, 10.		19	,,	1,144
,, 11.		31	,,	1,175
,, 12.		39	,,	1,214
,, 13.	(Sunday)	—		—
,, 14.		40	,,	1,254
,, 15.		33	,,	1,287
,, 16.		30	,,	1,317
,, 17.		29	,,	1,346
,, 18.		55	,,	1,401
,, 19.		49	,,	1,450
,, 20.	(Sunday)	—		—
,, 21.		27	,,	1,477
,, 22.		38	,,	1,515
,, 23.		35	,,	1,550
,, 24.	Bull-wheel broke down	12	,,	1,562
,, 25.		21	,,	1,583
,, 26.	Cable parted 9.30 p.m. Tools and 1,400 ft. of rope in hole	62	,,	1,645
,, 27.	(Sunday)	—		—
,, 28.	Fishing	—		—
,, 29.		17	,,	1,662
,, 30.	Struck the oil sand at 1,664 feet	9	,,	1,671
,, 31.		14	,,	1,685
Feb. 1.		14	,,	1,699
,, 2.		20	,,	1,719

Total time of drilling about 47 days; 66 days from time drilling began to completion of well. Average progress about 36½ ft. per day. Best 24 hours' work, 101 ft. Well drilled dry; cased at 435 ft. Torpedoed on completion, when it gave a heavy flow of oil for a short time, and afterwards yielded about 35 barrels per day.

Every oil well is naturally divisible into three sections, viz., (1) surface clays and gravels, (2) stratified rocks containing more or less water, (3) stratified rocks, seldom water-bearing, including the oil sands. The first division requires the conductor already described, and the second division requires casing to shut off the water from the third section. The earlier method of excluding the water, by placing a seed-bag round the tubing, has already been mentioned. This method was found unsatisfactory, as the tubing could not be removed for repairs without disturbing the seed-bag, and letting water into the well. In 1868 cast-iron drive pipe was adopted as a substitute for the wooden conductor used in the earlier wells. The most important alteration made in 1868 was, however, the introduction of 3¼-in. casing as a permanent fixture. This casing extended to the bottom of the water-bearing rocks, and was furnished either with the seed bag or with a leather cup, which was forced open against the sides of the well by the pressure of the water. The tubing, of 2¾-in. external diameter, and extending nearly to the bottom of the well, was then placed inside and suspended from the casing. To obtain a supply of water for the boiler, a small pipe was often inserted, between the tubing and the casing, into the water chamber above the seed-bag. Although the 1868 well was a great improvement on the earlier wells, it possessed defects. Thus the casing being 3¼-in. internal diameter, while the uncased part below it was 5½-in., fishing tools could not be easily introduced, and if it became necessary to deepen the well, only 3⅛-in. bits could be used. The improvements which followed are best exemplified by describing one of the wells of 1878. This well has an 8-in. wrought-iron drive pipe, armed at the bottom with a steel shoe. The pipe is driven down to the bed rock, and an 8-in., or, strictly speaking, 7⅞-in., hole is drilled to the base of the water-bearing strata. At this point, the bore is gradually reduced to 5½-in., and there a bevelled shoulder is made; 5½-in. casing, provided at the lower end with a collar to fit the bevelled shoulder, is then inserted, and a sufficiently water-tight joint is thus made. Drilling with 5½-in. bits is then continued until the required depth has been reached. When gas is obtained in sufficient quantity to furnish fuel for the boiler, it is conveyed through a 2-in. pipe connected with the casing beneath the derrick floor, and passing into the door of the furnace. A $\frac{1}{4}$-in. steam pipe, fitted with an elbow, and $\frac{1}{8}$-in. jet, is inserted in the gas pipe, close to the fire box, and a blast of steam is thus caused to issue with the gas. The apparatus acts as an exhauster, drawing the gas from the well, and preventing the flame from running back. The cost of a well in the Bradford field, in 1871, was about $3,000.

The "water-packer," introduced in 1875, is a device to prevent water that may pass into a well below the casing from gaining access to the oil-sand, and to stop the ascent of gas on the outside of the tubing. It is applied round the tubing at any desired point, and its effect is to shut off all communication between the annular space outside the tubing above it and the oil chamber below. The oil and gas are thus confined in the well chamber, and many wells are thus caused to flow that would otherwise require pumping. Under these circumstances the flow is intermittent, taking place when sufficient gas-pressure has accumulated. There are many forms of water-packer, but one of the simplest consists of a band of india-rubber which, on compression, is forced against the walls of the well. If the well does not flow, the oil requires to be raised to the surface by a pump. The working barrel of the pump is placed at the bottom of the well on the end of the tubing, a perforated piece of casing of proper length, termed the "anchor," being attached to the lower end of the working barrel. To the sucker of the pump the required number of wooden sucker-rods, screwed together, are attached, the upper end of the string of rods being connected with the walking-beam. There is, of course, a valve at the bottom of the working barrel, and in the sucker. The sucker is provided with a series of three or four leather cups, which are pressed against the working barrel by the weight of the column of oil. The sucker rods are of ash, $1\frac{1}{2}$ in. in diameter by 24 ft. to 28 ft. in length. When a number of contiguous wells are to be pumped, an arrangement termed a "grasshopper" apparatus is employed. By this means several wells can be pumped by the action of a single walking-beam.

Most petroleum wells in the United States are "torpedoed" on the completion of the drilling, in order to increase the flow of oil. The torpedo is a charge of nitro-glycerine in a suitable shell, which is lowered to the oil-bearing rock, and there exploded, with the effect of opening fissures into the surrounding rock. The shells, which are of tin plate, are of two kinds. One form is lowered to the bottom of the well by a string that can easily be detached, and rests on what is termed an "anchor," which is simply a cylindrical tin tube of such length as will bring the torpedo to the required position. To the upper end of the shell is fitted a "firing head" consisting of a circular plate of iron, only slightly smaller than the bore of the well, having projecting vertically downwards from its lower surface a rod on which a percussion cap is placed. Beneath the cap is an anvil. The lowering cord having been detached and drawn up, a cast iron weight, termed a "go devil," is dropped into the well, and this weight striking the disc explodes the percussion cap and fires the torpedo. The other form of shell is suspended by a cord, which serves as a guide for a perforated weight running on it. The usual size of the former description of shell is $3\frac{1}{2}$ inches diameter by 10 feet in length, a shell of these dimensions holding twenty quarts of nitroglycerine. Frequently as large a charge as eighty quarts is used, and it is then usual to employ four shells of the dimensions given, the lower end of one fitting into the upper end of another, and only the top shell of the series having the firing head. Shells of the other description are commonly termed squibs. They are of much smaller dimensions, holding only about a quart of the explosive liquid, and are now generally used to bring about the explosion of the large torpedo. I extract the following from the *Petroleum Age* for last August:—

> "There are nine glycerine firms at work in the Bradford field, and all their men are kept busy from morning till night. The size of the shot used is rarely less than eighty quarts. The constant enlargement of the cavity in the oil-bearing rocks necessitates the use of dynamite squibs for exploding the shells, and the old method of dropping a 'go-devil' on the firing-head of the torpedo has been almost entirely superseded. The cans in which the nitro-glycerine is transported about the field have been enlarged from six to eight quarts capacity, and each shooter's waggon carries ten cans, or eighty quarts of the powerful explosive. It is estimated that over eight tons of glycerine were used in the Bradford field during the month of July."

Specimens of the two kinds of torpedoes, and of the appliances for exploding them, for which I am indebted to Mr. William M. Irish, of Olean, New York, are before you. The torpedo is usually exploded under about 50 feet of water. Little or no sound is heard, but a slight quiver of the ground is often perceptible. A few moments after the explosion, however, the fluid in the well is shot into the air with great violence, forming a magnificent fountain, and small pieces of rock are also thrown out. The torpedo and exploding weight are blown into small fragments. I have on the table specimens of the sand-rock thus ejected, and among them is a portion of the tin shell of the torpedo. A few minutes later the well begins to flow, but there is usually a sufficient interval to admit of the casing being connected with a tank in which the oil is collected. The torpedo was invented by Colonel Roberts, and patented by him in 1864.

The operation of torpedoing is conducted by a company who purchased Roberts's patent. The nitro-glycerine is conveyed to the wells in tin cans, placed in padded compartments in a light spring waggon. Considerable recklessness is often displayed in driving these waggons over the rough roads, and waggon, horse, and rider, are sometimes blown to pieces by the explosion of the material. The charges of the company being high, attempts are made by well owners to prepare their own torpedoes. The persons who are employed in this secret service are termed "moonlighters." Another way in which payment to the company is largely evaded is to secretly place in the well a shell containing a large quantity of nitro-glycerine, and then to order the company to explode a small charge. The whole of the explosive material is thus fired, and the company's agent receives payment on the basis of, say, 10 quarts of nitro-glycerine, and leaves the well, little thinking that he has exploded perhaps 60 quarts or more.

Some authorities are of opinion that the use of the torpedo is of little value, its effect being simply to clear the pores of the rock of obstructions, and the apparent increase in the yield of oil being simply due to reaction from the immense gas pressure produced by the explosion. Many wells, however, that produced no oil on the completion of the drilling (technically termed "dry-holes") have, through the use of the torpedo, been caused to yield abundantly. In Russia the torpedo is never used.

A modification of the rope system of drilling, known as the rod system, is adopted in Russia and in Galicia. The rod system consists in the substitution of rods of 40 to 60 feet in length, screwed together, for the portion of the drilling cable which passes from the end of the walking beam to the string of tools. Iron rods are used in Russia, and wooden rods in Galicia. In the latter country, where the character of the strata is such that the drilling is difficult, and the hole very liable to depart from the vertical line, in which case the well is rendered useless; the rods, in some cases, work in guides. The rod system is stated by some authorities to be preferable to the rope system for use in Russia, and also in Canada, but it is a less expeditious method of drilling, the time occupied in disconnecting the rods, when the tools are drawn up for the removal of the pulverised rock, and the sharpening of the bit, being considerable, especially when the well has become deep. In Russia it is usual to commence drilling with a bit as much as 15 inches or 16 inches, or even more, in diameter, but it is generally found necessary to gradually diminish the size of the bit as the drilling proceeds.

Vasilieff, whose paper I referred to in the last lecture, states that the cost of the 16-inch, 14-inch, and 12-inch casing pipes for a well in the Baku oil-field 600 feet deep, amounts to £510, and that the additional expense for labour exceeds £1,000. The rates of wages are as follows;—Engine-drivers, with a house, £8 to £10 per month; fitters, 5s. per day; turners and smiths, 6s. per day; carpenters, 4s. per day; labourers, from £1 16s. to £2 per month, except in the case of Persians, who work for £1 to £1 4s. per month. The average rate of sinking is 140 feet per month. In consequence of the extreme pressure of the gas, amounting sometimes to as much as 300 lbs. per square inch, it is found difficult to prevent the oil from escaping between the casing and the ground. This difficulty has been overcome by sinking an octagonal well about six feet in diameter, and some forty feet in depth, down to the hard ground, and filling in the space round the casing with masonry in cement; or by tamping the space with puddled clay, after the joint between the casing and the hard ground has been caulked with rope-packing.

The depth of the petroleum wells in the United States increased from 436 ft. in 1861, to 1,606 ft. or more in 1878. There has been a further increase in depth since the latter year, especially in certain localities. Thus the comparatively recently drilled Gordon well in Washington County has a depth of 2,400 feet.

The cost of this well is stated to have been $7,500 to $8,000.

The average depth of the petroleum wells in the Caucasus has also been progressive, having increased from 154 ft. in 1873, to 450 ft. in 1884. Certain of the wells are, however, much deeper, one that I saw spouting having a depth of 721 ft. It has been estimated that the average level of the oil in the Baku (Balakhani-Saboontchi) oil-field is lowered to the extent of 56 ft. for every 500,000,000 gallons extracted.

The irregular character of the strata renders the operation of well-drilling, as a rule, more costly in Southern Russia than in the United States, the expense of a well in the Baku district being stated at from £1,000 to £3,000, according to circumstances.

Mr. George Adams informs me that the depth of the wells in Galicia ranges from 250 to 350 metres.

The yield of petroleum wells varies greatly. Of the producing wells in the United States, numbering 20,000, or more, the great majority furnish only a few barrels of oil per day, but some are stated to have yielded, for a short time, as much as 260,000 gallons per 24 hours. This splendid yield is, however, completely eclipsed by that of some of the wells in the Baku district. In well-drilling in the latter locality, it is usual to affix to the top of the casing a strong iron cap, provided with a sliding valve, as soon as the oil is "struck." The petroleum is thus bottled up, and is only drawn off as required. When in Baku, in the autumn of 1884, I saw, through the courtesy of Messrs. Nobel Brothers, one of these capped wells opened. On drawing the slide, a mighty column of crude petroleum, more than a foot in diameter, immediately shot up to a height of over 100 feet, with a roar, and this magnificent fountain continued to play as long as the valve remained open, forming a lake of oil in the neighbourhood of the derrick. This well yields at the rate of 1,125,000 gallons per 24 hours whenever opened. The celebrated Droojba well, and one of Nobel's wells, both yielded, however, for some time, about double that quantity. In the case of the Droojba well, the flow commenced before the cap could be fixed, and the well was for four months quite uncontrollable, sending up a fountain to a height of 200 to 300 feet, and deluging the surrounding land with the oil. The sand thrown up with the oil did considerable damage to neighbouring property, engine-houses and workshops being partially buried in it. The use of the caps is not free from difficulty, for the oil contains so much sand, that in its rapid flow under the great pressure prevailing, a considerable thickness of iron is quickly cut through. The principle of capping wells is not adopted in the United States, the object there being to drill the territory acquired as quickly as possible, and take out the oil. It has been demonstrated in the United States that there is a lateral flow of oil through the oil-sand (in one instance red paint put into a well was pumped out of another about half-a-mile distant), and it is therefore impossible for an owner or lessee of oil territory to preserve the oil beneath the surface. The oil must be raised, or it would be drained away by wells on neighbouring property.

The average length of time during which an oil well in the United States will yield oil in remunerative quantity has been estimated at five years, but, from what has been stated, it will be apparent that the period must necessarily vary within very wide limits.

The pressure of the oil in the Baku capped wells is frequently as much as 200 lbs., or even in some cases probably 300 lbs., per square inch, and although the upper part of the casing is anchored to the ground, there is some danger of the fittings being blown off when the valve is closed after drawing off a supply of oil. There are about 400 wells in the Baku district, but at the time of my visit only some 100 of these were productive,* and of the latter not more than 20 were flowing wells. These 20 wells would, however, for a time, yield more than enough crude oil for the manufacture of the 1,800,000 to 2,000,000 gallons of burning oil which the world daily consumes. Wells in the Baku district which do not flow cannot be pumped in the ordinary way, in consequence of the large quantity of sand present (sometimes as much as 30 to 40 per cent.), and the oil is raised to the surface in cylinders resembling the sand-pump already described. The cylinder used commonly holds 45 gallons, and it is stated that from 18,000 to 20,000 gallons can thus be raised from each well in a working day of 10 hours.

The gas-wells in the United States are similar to the oil-wells, the casing heads of some that I saw in the neighbourhood of Clarksville last autumn being firmly secured to the ground by chains.

According to Mr. Carnegie, the largest gas-well known yields about 30,000,000 cubic feet of gas in 24 hours, but half this quantity may be considered as the product of a good gas-well. The pressure of the gas at the mouth of one of these wells was shown by the gauge to be 187 lbs. on the square inch, and at the works where the gas was used, nine miles from the well, the pressure was 75 lbs. per inch.

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* Vasilieff gives the average yield of these 100 wells as 32 tons per well per day.

The drilling of wells is an operation by no means free from risk. Occasionally, when oil is struck, the outrush is so violent that the ponderous drilling tools are projected from the well, and the liberated gas is liable to take fire. Dr. Gesner gives the following description of an accident of this class, which occurred in the early days of the industry:—

> "We had gone down 300 feet, and were expecting to strike oil at any moment. We went up to the shanty where we boarded, to supper, and on our way back to the well, which was just below in the hollow, we saw the men hurrahing, and presently a jet of gas, water, and oil rushed up, fairly lifting the tools out of the well. It roared and hissed like letting off steam from a boiler. The stream seemed to me to mount higher than the derrick, which was 40 feet high. The folks in the neighbourhood ran down with their shovels, and dug a circular trench around the well, throwing up a bank to catch the oil, as we had not expected such a flood, and had no large tanks ready. The gas mingled with the air, and for a distance about the well the air was almost yellow with the gas and spray of oil from the fountain. Mr. R. and myself looked on awhile, and then started to go to the engine-house of the next well to have the fires put out. Before we reached it, however, the gas took fire like a flash of lightning. Mr. R., who was passing a small tank of oil, was covered with it as it took fire also, and I lost sight of him for a moment. My hair and face were burned, but I was not much hurt. The sight of the burning well was terrible. A great fountain of fire, it wavered to and fro as the wind took it, and threw off blazing jets of oil. The poor people who were dipping the oil up in the little pool around the well wilted down like leaves when the forest is on fire. Some tried to crawl away, but the liquid flame ran along the ground and caught them. Several hundred barrels of oil from a neighbouring well caught fire. Vast clouds of smoke rose from the burning well, and floated off over the hills; and when night set in, the clouds and hills were red with the light of the conflagration. Mr. R. died very soon after. There were a great many lives lost."

In December, 1884, a burning well in the Thorn Creek district, estimated to be discharging more than 2,500 barrels of oil per day, created a great sensation, the column of flame being 175 feet in height.

When wells have ceased to yield oil in remunerative quantity in the United States, it is usual to draw out the iron casing for use in other wells; but as this operation allows surface water to gain access to the oil-sand, and as it has been found that the yield of adjacent wells is prejudicially affected by this "flooding," as it is termed, the Pennsylvania Legislature enacted that abandoned wells should be "plugged" by filling them with sand. The prejudicial effect of the flooding of the oil-bearing strata has, it appears, recently been experienced in the Caucasus, the per-centage of water in the oil raised in that locality being, according to Vasilieff, steadily on the increase.

When the oil has reached the surface, either by flowing or being pumped, it is conducted into a tank, usually of wood, holding about 250 barrels. In America, I may mention, quantities of crude petroleum are alway stated in "barrels" of 42 American gallons (5 American gallons = 4 Imperial gallons). In the early days of the industry, in the United States, the only method of transporting the oil from the well was to place it in oak barrels holding 40 or 50 gallons, and to convey these barrels by road to Oil Creek, where their contents were emptied into bulk barges holding about 2,000 barrels. As Oil Creek was not navigable, arrangements were made with mill owners for the use of the surplus water stored in the dams, and at intervals the barges were floated down from dam to dam until they reached the mouth of the Creek at its junction with the Alleghany River, from which point there was good flat-boat navigation to Pittsburg. This method of transportation was not only very costly, but was also attended with frequent loss of oil through the barges coming into collision while being floated down. On one occasion, from 20,000 to 30,000 barrels of oil were thus lost. Added to this, the roads over which the barrels had to be drawn to the water were little better than paths through the woods, and from my experience of these in the winter, I can readily believe that they were often quite impassable. Nevertheless, the system, for want of a better, was for some time largely adopted, over 1,000 boats, 40 steamers, and 4,000 men being engaged in the traffic.

In the latter part of 1862, a branch of the Atlantic and Great Western Railway was carried into the oil regions, and at a later date the Alleghany Valley Railway was opened up from Oil City, at the mouth of Oil Creek, to Pittsburg, and a number of narrow-guage railways were constructed as feeders.

Crude oil was at first conveyed by rail, in barrels coated internally with glue, but the small quantity of water present in the oil was found to dissolve the glue, and cause the barrels to leak. To remove this difficulty, and to reduce the cost of handling the oil, tank waggons were adopted in 1865 or 1866. These waggons at first consisted of an ordinary truck, on which were placed two circular wooden tanks, or tubs, holding from 2,000 to 4,000 gallons. In 1871, the tank car now employed was introduced. This consists of a cylinder of boiler-plate, lying upon a four-wheeled truck, and provided with a dome similar to that which a horizontal steam-boiler has. The tank is furnished with means of filling at the top, and with a valve beneath by which it can be emptied. The tank is now usually about 24 ft. 6 in. in length by 66 in. in diameter, and holds from 4,500 to 5,000 gallons.

Tank barges, 130 ft. by 22 ft. by 16 ft., divided into eight compartments with water-tight bulk-heads, and holding 2,200 barrels, are also at present used for the conveyance of crude oil on the Alleghany river.

In 1862, a Bill was introduced into the Pennsylvania Legislature for a pipe-line from Oil Creek to Kitanning, but this and a subsequent scheme for laying a pipe-line down the Alleghany river to Pittsburg, were strongly opposed and came to nothing. According to Mr. C. L. Wheeler, the credit of having first suggested the laying of a pipe-line belongs to General Karns, while a Mr. Hutchinson was the first to carry out the idea. Hutchinson's pipe, which was only about three miles in length, was however defectively constructed, and leaked so much that little if any of the oil run in at one end reached the other. Mr. Peckham states that the first successful pipe was laid by Van Syckle, of Titusville, in 1865. This line, which was four miles in length, and another, were afterwards worked by the Alleghany Transportation Company, though not at first without considerable opposition from the teamsters, who more than once maliciously severed the pipes. However, by the employment of armed patrols, the lines were preserved from destruction, and after a time the opposition ceased. Gradually a system of pipe-lines, running from the wells to central stations and thence to loading stages on the railway lines, was constructed, and in 1876 there were eight or nine companies owning pipe-lines in the oil regions, and issuing negotiable certificates for the oil which they collected.

At the present time there is in the oil regions of the United States a complete network of 2-in. piping connecting the various wells with storage tanks and trunk lines. These pipes run across country and through streets; it is impossible to get any accurate statistics of their collective length, but it is safe to say that there are thousands of miles of this 2-in. piping thus employed in the collection of the crude oil.

In 1875, the first trunk line was laid. This extended from the lower oil country to Pittsburg, a distance of sixty miles, and was 4 in. in diameter. Like the first pipe-lines from the wells it had for a time to be protected by armed men.

As the refining trade developed it became concentrated on the seaboard and on the shore of Lake Erie, and the transportation of the crude material to the refineries became a business of very great importance. From 1878 to 1881-2, the construction of great trunk lines was continuous. Consolidation of the transporting companies also took place, and at the present time the pipe-lines, with one exception, are under the control of a very wealthy corporation, known as the National Transit Company, which is said to have $15,000,000 invested in oil-transporting plant. This company owns the following lines:—

		Miles.
From Olean, N.Y., to New York, Bayonne and Brooklyn	(length)	300
From Colegrove, Pa., to Philadelphia	,,	280
From Millway, Pa., to Baltimore	,,	70
From Hilliards, Pa., to Cleveland	,,	100
From Four Mile, Cattaraugus Co., N.Y., to Buffalo	,,	70
From Carbon Centre, Butler Co., Pa., to Pittsburg	,,	60

A total, including the duplicate lines, of about 1,330 miles. The New York line consists of two 6-in. tubes for the entire distance, with a third 6-in. tube for a portion of the way, and is provided with eleven pumping stations about 28 miles apart. The transporting capacity of this line is about 28,000 barrels per day. The greatest elevation of the pipe between stations above tide-water is 2,490 feet. The Philadelphia pipe has a diameter of 6 in. with six stations; the Baltimore pipe is 5 in. in diameter without a break; the Cleveland pipe 5 in. with four stations; and the Buffalo and Pittsburg pipes 4 in. with two stations.

The pipe is made specially, and is of wrought-iron, lap-welded. It is tested to a pressure of 1,500 lbs. per square inch, the working pressure being 900 to 1,200, or even sometimes 1,500 lbs. The pipe is in lengths of 18 ft., provided at each end with coarse and sharp taper threads, nine to the inch, and the lengths are connected with long sleeve couplings, also screwed taper. The line is usually laid two or three feet below the surface of the ground, though in some places it is exposed, and at intervals bends are provided to allow for contraction and expansion. At the different pumping stations there are storage tanks of light boiler plate, usually 90 feet in diameter by 30 feet in height, the oil being pumped from the tanks at one station to those at the next, though sometimes loops are laid round the stations, and oil has thus been pumped a distance of 110 miles with one engine. The pumping engines chiefly employed are the Worthington engines, constructed at the Worthington Works in New York, and at each station there is usually a duplicate set. The characteristics of these pumps are, according to the *New York Engineering News*, independent plungers with exterior packing, valve boxes subdivided into small chambers, and leather-lined metallic valves with low lift and large surfaces. The engines vary in size from 200 to 800 horse-power. The pumps are so constructed that before one plunger has completed its stroke another has taken up the work. The column of oil is thus kept continuously in motion, and the violent concussions which occur when the oil column is allowed to come to rest between the strokes are avoided.

I visited the Olean station of the New York line last autumn, and was much struck with the smooth working of the Worthington engine, as well as the very limited fluctuations of pressure. At the time of my visit the pressure, under which the oil was being driven a distance of 28 miles, averaged 900 lbs. per square inch. In the older systems of pumping the concussions sometimes resembled the report of a gun, the pipes soon being rendered defective by this intermittent strain.

Besides the tanks at the pumping stations, the National Transit Company owns an immense amount of tankage at convenient centres of distribution, and has, at the present time, no less than 35,000,000 barrels of petroleum in its custody.

The tanks usually hold about 30,000 barrels. They are of boiler plate, roofed with wood, covered with sheet iron, the roof being usually slightly conical.

The system of issuing certificates for the crude oil stored, to which I have already referred, is adopted by the National Transit Company. When a producer has filled the tank at his well, he summons an officer of the company, who, in association with the well owner, gauges the quantity of oil, issues a voucher for the amount, less 3 per cent. to cover loss in transit, and runs the oil into the company's pipes. The oil thus received by the company is treated like a deposit in a bank, and is transferable by written order. Such order, when accepted by the company, is known as a certificate, but as dealings on the Oil Exchange are usually on the basis of 1,000 barrels, certificates are, as far as possible, made out only for this quantity. The oil is held rent free for 30 days, and at the expiration of this time a charge is made for storage. Only a limited amount of classification of the crude oil in the pipe line system is possible,* and obviously the oil from a particular well loses its identity as soon as it passes into the company's pipes. The heavy oil from the Franklin and other districts, and also some of the lighter crude oils are, therefore, transported in barrels.

The National Transit Company has an independent telegraph system extending to every point on its lines.

The trunk line to which I alluded when stating that the lines were, with one exception, under the control of the National Transit Company, is owned by the Tidewater Pipe Company. This line, which consists of one pipe 6 in. in diameter, extends from Rixford, in the Bradford field (about eight miles as the crow flies south-east of the town of Bradford), in a general south-easterly direction, to Tamanend, in Schuylkill county; there the oil is transferred to tank cars, and conveyed by the Reading Railroad to Chester, a town fifteen miles from Philadelphia, or to Bayonne, New Jersey. From Rixford to Tamanend is a distance of about 170 miles, and in this distance there are five pumping stations. Instead of the stations being placed, as they are on the National Transit Company's lines, at pretty regular distances of twenty-five or thirty miles apart, they are separated by intervals corresponding in some measure with the incline, the greatest distance being fifty-five miles, and the shortest twenty-four miles. By the use of loop lines round the stations, the oil is, however, frequently pumped, in hot weather, when it is most fluid, a distance of eighty miles. The working pressure is 1,000 lbs. per square inch, and the capacity of the line 10,000 barrels per twenty-four hours. At this high pressure leaks occasionally occur, and I was informed that workmen have had their hands cut to the bone by the fine stream of oil issuing from some minute orifice when engaged in stopping the leaks.

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* A notice issued by the National Transit Company o the 3rd August last, was to the following effect:—"On and after this date, and until further notice, crude oil produced in the counties of Forrest and Warren will be classed as 'Middle District Oil,' and that produced in Butler, Armstrong, and Clarion counties, as 'Lower District Oil.' Oil produced in each of these districts will be kept separate from other oils, and will be delivered in kind as received, upon the receipt of order against a credit balance."

The Holly Pump, which is a three-throw pump with gearing, is used on the Tidewater Line.

A very interesting feature of the pipe line system of transportation is the arrangement adopted for cleaning the pipes, and removing obstructions caused by sediment. The apparatus used is termed a "go-devil," a name which, as we have seen, is also applied to the iron weight which serves to explode the torpedo. The pipe-cleaning "go-devil" consists in many cases of a brush of steel wire of conical form, fitted, at the base or rear end of the cone, with a leather valve in four sections, strengthened with brass-plates, and also furnished with long steel wire guides. This instrument is impelled by the stream of oil, and travels at the rate of about three miles an hour. Its progress can be traced by the scraping sound which it makes, and it is followed from one pumping station to another by relays of men on foot. It must never be allowed to get out of hearing, otherwise, in the event of its progress being arrested by an obstruction, it may be necessary to take up a considerable length of piping to ascertain its position.

It is by no means uncommon for storage tanks of crude petroleum to be set on fire by lightning, notwithstanding the general employment of lightning conductors, the vapour which the oil evolves readily taking fire, and communicating flame to the oil. When a tank has taken fire, the oil usually boils over, and to prevent this, holes through which the oil may escape are made by firing round shot at the tank from small cannon. Such fires are occasionally of great magnitude, and, as may be imagined, involve no small danger to surrounding property.

We have now to consider the method of transportation of crude petroleum in the Caucasus. Up to the year 1876, the transport of oil in this locality took place in large barrels, which were conveyed from the wells to the refineries in primitive two-wheeled Persian carts, termed "arbas," one barrel being placed in the body of the vehicle, and another slung between the lofty wheels. Thousands of these carts were at one time in use, and it is stated that as much as £100,000 per annum has been paid to the carters for this method of transportation. Messrs. Nobel Brothers were the first to substitute a pipe line for the "arba" system of conveyance, and their example being soon followed, there are now seven, or more, pipes connecting the Balakhani-Saboontchi oil-field, with the Baku refineries some eight or nine miles distant. Of these lines, Messrs. Nobel own the two largest, of the respective diameters of 6 in. and 5 in. Messrs. Nobel's first line is stated to have cost £10,000, and the average cost of a 6-in. line is stated by Mr. Marvin to be about 8,000 roubles per verst. Messrs. Nobel's experiment was attended by the same difficulties that, as I have already stated, were experienced in laying the first pipe-lines in the United States, the native carters strenuously opposing the interference with their business, and the greater lawlessness prevailing in the Caucasus, and the ferocity of the opponents, rendering the task of protecting the line one of no small difficulty and danger. It was, in fact, found necessary to erect a series of watch-houses along the route, in which armed men were stationed. These watch-houses were still standing when I visited the district, but all active opposition having long since ceased, they are no longer devoted to their original use. The capacity of the seven pipe-lines is estimated at more than 700,000,000 gallons per annum. A considerable quantity of crude oil is also transported in tank waggons by rail.

I shall have occasion, in the succeeding lecture, to refer to the transport of the refined oil in Russia in tank waggons by the Trans-Caucasian and other railways, and to the project of laying a pipe-line for the conveyance of this product from the Baku refineries to the shores of the Black Sea. An alternative proposal has, however, recently received consideration at the hands of a commission under the auspices of the Ministry of Ways of Communication. This proposal is to construct a pipe-line from Baku to Batoum, for the transport of the crude oil, and to establish a refining industry on the Black Sea coast.

The ozokerit of Galicia is obtained by sinking shafts, from 130 ft. to 260 ft. in depth, to the beds or pockets in which the material occurs, and then driving tunnels. The shafts generally pass through about 25 ft. or 30 ft. of gravel or boulders, and then through blue loam and plastic clay. In this clay, usually at a depth of 140 ft. to 150 ft. from the surface of the ground, the ozokerit, or earth wax, is found in layers of from 1 ft. to 3 ft. in thickness, the purest being of a honey yellow colour, and of the hardness of beeswax. Much of the ozokerit is, however, in small pieces, and is obtained in admixture with earthy matter, from which it is separated by fusion.

Miscellaneous.

OLONIAL AND INDIAN EXHIBITION.

Arrangements have been made for the examination in the Indian Court of certain commercial products, which are believed to be either insufficiently known, or to be suitable for new purposes.

These Conferences are being held in the Commercial-room attached to the Imperial Court.

The following are the arrangements; the first four meetings have already been held:—

Wednesday, June 16.—"Fibres suitable for Textile Purposes." 3 to 5 p.m.
Friday, June 18.—"Silk and Silk Substitutes." 3 to 5 p.m.
Monday, June 21.—"Drugs, including Cinchona." 3 to 5 p.m.
Wednesday, June 23.—"Tobacco." 3 to 5 p.m.
Friday, June 25.—"Fibres suitable for Textile Purposes." 3 to 5 p.m.
Monday, June 28.—"Gums and Resins, including Lac and Cutch." 3 to 5 p.m.
Wednesday, June 30.—"Minerals." 3 to 5 p.m.
Friday, July 2.—"Fibres suitable for Paper-making." 3 to 5 p m.
Monday, July 5.—"Oil, Oil-seeds, and Perfumery." 3 to 5 p.m.
Wednesday, July 7.—Dyes, Mordants, and Pigments." 3 to 5 p.m.
Friday, July 9.—"Fibres suitable for Mats, Ropes, also Basket-work and Brushes." 3 to 5 p.m.
Monday, July 12.—"Timbers." 3 to 5 p.m.
Wednesday, July 14.—"Tanning Materials and Leather." 3 to 5 p.m.
Friday, July 16.—"Food Stuffs." 3 to 5 p.m.

Gentlemen desirous of attending any of the meetings should communicate with Mr. E. C. Buck, Secretary to the Government of India in the Department of Revenue and Agriculture, at the Exhibiton.

The number of visitors to the Exhibition for the week ending June 19th, was 252,633; making a total since the opening of 1,126,202. On Whit Monday 80,294 persons visited the Exhibition; this is the highest number which has ever visited any one of the Exhibitions in one day; the numbers on Whit Monday at the previous Exhibitions were:—Inventions, 73,634; Health, 64,679; Fisheries, 42,941. By Whit Tuesday, the thirty-seventh day since the opening, more than one million visitors had passed the turnstiles. At the three previous Exhibitions one million visitors were reached as follows:—Inventions, in 45 days; Health, in 51 days; Fisheries, in 68 days.

LEATHER INDUSTRY IN CATALONIA.

The manufacture of, and trade in hides, skins, and leather is of considerable importance, owing, in a great measure, to the development of mechanical industries, and also to the constant increase of the use of leather boots and shoes in Spain and its colonies. Consul Scheuch says that Spain itself furnishes certain quantities of horse and ox hides; the greater part, however, are imported from the River Plate, Porto Rico, Uruquay, and Brazil, from France and England, and in smaller quantities from Germany, Mexico, the United States, Algiers, Portugal, and the Canary Islands. The hides most preferred and commanding the highest prices are from the slaughter-houses of Bordeaux and Paris, and next are those from South America and the Spanish provinces of Cordova and Granada. The best calf are chiefly imported from Hamburg. The sheep skins most appreciated for tanning are those weighing from 19 kilogrammes and upwards. Sheep furnishing this kind are killed throughout Spain, but those in best condition, owing to the better pasture and healthier development, are from the Mancha and Estramadura districts, and the outlying country beyond the cities of Tarragona and Valencia. Lamb skins are received from the Catalan towns of Manresa, Vich, Olot, Figueras, Gerona, and Ampurdan. The principal cities or towns interested in the manufacture of leather and their specialties, are as follows:—Igualada and Manresa, sole leather; Figueras, straps and belting; Ripoll, oak tanned sheep skins; Reus, sumac tanned sheep skins; Vich, chamois leather; and Barcelona, besides the former, fine white and coloured leather, called *tafilites*. The substances principally employed in Catalonia for tanning skins are (1) oak bark, gathered in spring when it contains the greatest quantity of tannic acid; (2) pine bark, which is imported chiefly from the Balearic Islands; (3) sumac leaves and stems of the bush of that name, largely imported from Syria, Turkey, and Greece; and (4) ruldo, a native plant of Catalonia. This later substance, being the cheapest and most easily obtained, is the most extensively used. As it is practised in Catalonia, tanning with oak bark comprises several operations, comprising the cleaning of the skins or hides both on the exterior or hair side, and the side next to the flesh, the tanning proper, and the dressing for merchantable leather. The cleaning of the skin comprises four secondary operations, the softening, the cleaning of the hair side, the cleaning of the flesh side, and swelling the cleaned skins. For the latter process the skins must first acquire a uniform softness, all creases and stiffness must disappear, and all particles of flesh and blood separated. In fresh hides these objects are attained by leaving them in running water, or troughs, two or three days. When the hides are dry or salted they are kept in the water from eight to ten days, and if running water is employed the hides are placed so that the current runs against the hair in order that the water should have full action on the entire surface of the skin. After they are well softened, they are cleaned first on the side next to the flesh, and afterwards on the hair side. The first operation requires much skill and care. The skins are stretched on a semi-cylindrical piece of wood, one end resting on the ground, the other on a block; the operator uses a knife with two handles and a blunt edge, and passing it over the skin from the block to the ground separates all grease, and whatever particles of flesh that may have remained after washing. The skin is then replaced in the water, and after twenty-four hours again scraped, beaten, and the water allowed to drain off. After cleaning the fleshy side, the skin is treated for the hair or wool side. This is done in various manners, generally by the use of lime, which is applied in a layer on the flesh side after the hide has been well softened and washed. With sheep skins, where the wool is to be preserved, and which would be damaged by contact with the lime, the skins are doubled up so as to show only the woolly side. The lime lays between the two contiguous portions of the inside and gradually penetrates the skin. This is effected in winter in fourteen or fifteen days, and in summer in nine to ten days, when the wool is easily separated. If, however, instead of sheep skins where the wool is to be preserved for other uses, the herds of other animals are to be treated, the process is much more simple. The skins are thrown into ditches dug for the purpose in the ground, and partially filled with strong lime. There are several ditches, each containing lye of different strength, to be used according to the different conditions of the skin. The lye is frequently stirred, and the skins are taken out and replaced twice a day; this treatment continues for days, sometimes for two or three weeks. The lime frees the skins completely from hair, and changes the grease contained in them into lime soap, which though insoluble in water, is easily separated in the swelling process, which frees the skins from the lime absorbed and the soap formed, and consists in the application of barley and bran that have undergone acid fermentation. The skins, when well cleaned, are ready to go to the tanning pits. These are wooden trenches of oak or pine, impenetrable to water, sunk in the ground, or else of masonry well cemented. Each one is capable of receiving from fifty to sixty hides. Before placing the hides, the bottom is covered with a layer of two to three inches of old oak bark, and above this another layer of fresh bark about an inch and a half thick. On this is laid with the hair side downwards, a skin, and then another layer of bark, and so on until the pit is full. Fresh bark is then filled in all crevices, and a final cover of the same from twelve to fourteen inches thick. The skins are then allowed to remain eight or ten weeks, till a strong odour of fermentation is given off, when they are taken out and placed in another pit, where they remain four to five months, during which the tannin penetrates through and through. They are again taken out and placed into another pit containing less bark than the former two, and kept therein four to five months longer, so that the skins in all, remain about one year in contact with the bark. Hides intended for belting and straps, are generally left in the tanning pits two years; oak-tanned sheep skins for shoemaking purposes only three months; sheep skins tanned with pine bark, mixed with ruldo, and expected to be used for moroccos and leather for bookbinding, need only one month's tanning, and others even less time. The skins after being taken out of the pits are washed twice, first in water already used for the same purpose, and then in clear fresh water. Consul Scheuch says, "the process of tanning, as practised in Catalonia, is the same in all Spain, but while in the other provinces the leather is placed upon the market in an incomplete state, this is not so in Catalonia, where all the different operations are gone through with to the end, so that the half or unfinished leathers from the other provinces are completed here."

CRYSTALLIZED FRUIT TRADE IN FRANCE.

The business of preserving fruit by the crystallizing process is peculiar to South-Eastern France, and is practised on a large scale at Apt, in the department of Vaucluse, at Clermont, in Auvergne, as well as at Marseilles, Grasse, Avignon, and other important places. The product is largely exported to England, the United States, and various other countries, including Algiers, the East and West Indies, and South America. Consul Mason, of Marseilles, says that the kinds of fruits preserved by the process of crystallization are mainly pears, cherries, apricots, pineapples, plums, figs, citrons, oranges, melons, and a kind of dwarf orange called *chinois*, which grows to some extent in the district of Nice, but is imported mainly from Italy and Corsica. Peaches are used only to a limited extent, in the region of Marseilles. The process of crystallizing is as follows:—The fruit is first carefully assorted in respect to size and uniform degrees of ripeness. Pears, pineapples, and quinces are peeled, citrons are cut into quarters, and soaked for a month in sea water, and the stones of apricots, cherries, and peaches are carefully removed. This preparatory process requires a certain degree of skill, since the stone must be removed with as little injury as possible to the form and solidity of the fruit. This work is performed mainly by women, and is paid for at the rate of about 2s. a day. Thus prepared, the fruit is immersed in boiling water, which quickly penetrates the pulp, dissolving and diluting the juice, which is thereby nearly eliminated, when the fruit is subsequently taken from the water and drained, leaving only the solid portion of the fruit intact. It is necessary that this process, which is termed "blanching," should be performed with the very greatest care, the period of immersion in the hot water being determined by the size and ripeness of the fruit. If immersed too long, the pulp is either cooked too much, or is left too dry and woody. If taken out too soon, the juices left in the pulp prevent perfect absorption of the sugar afterwards, and, by eventually causing fermentation, destroy the value of the product. After being scalded, some of the fruits, especially apricots, are again assorted into two or three classes, according to the degree of softness that has been produced, as, if they are kept together, they would take up the sugar differently, some losing their form entirely, while others would remain insufficiently impregnated. For these different grades, sugar syrups of different degrees of density are required, the softer the fruit, the stronger the syrup required for its preservation. For the same reason, each of the different varieties of fruit requires a syrup of corresponding strength. Pears, citrons, and pineapples, which remain hard and firm, take best a syrup having a density of from 18° to 25°, while apricots, plums, and figs are treated with syrups which gauge from 30° to 42° by the aerometer. The requisite syrup having been prepared by dissolving the fruit in pure water, the fruit is immersed in it, and left, for a certain period, in large earthenware pans, glazed inside, and having a capacity of about eight gallons. The syrup penetrates the pulp, and gradually withdraws and replaces the remaining fruity juice, which, as it exudes and mingles with the transparent liquid, produces a certain filmy or clouded appearance, which marks the commencement of fermentation. When this has reached a certain stage, the vessel containing the syrup and fruit is placed over the fire and heated to 212° Fahrenheit. This corrects the fermentation, and raises all impurities to the surface, whence they are removed by skimming. If the syrup is of proper density, this process of impregnating the fruit with sugar will be complete in about six weeks, during which time it is usually necessary to perform this heating operation, as above described, three times. The impregnation of the fruit with sugar being thus complete, it is taken out, washed in pure water, to remove the flaky particles that adhere, and is then submitted to one or two finishing processes as follows:—If the fruit is to be "glacéd"—that is, covered with an ice or transparent coating—it is dipped in a thick viscid syrup of sugar, and left to dry and harden rapidly in the open air. If it is to be "crystallized," it is dipped into the same syrup, but is then cooled and dried slowly in a kiln or chamber, warmed to a temperature of 90° Fahrenheit. This slow process of cooling causes the thick syrup with which the fruit is covered to crystallize, and assume the usual granulated appearance. The operation is then complete. It is stated that the fruit thus preserved will bear transportation to any climate, and will keep firm and unchanged for years. During the process of impregnating the fruit with sugar, the syrup in which it is immersed is gradually deteriorated by losing its sugar and absorbing the juices of the fruit. It is finally utilised in the preparation of *confiture d'Apt*, which is made of the soft uncooked and irregular pieces of fruit of all kinds, mixed in irregular proportion, and preserved in the spent syrup, which is boiled down to the required consistency. The net cost of preserving fruit in France by the crystallizing process varies with the price of sugar and labour, but it is estimated that in the year 1885 it was at the rate of about 1s. the pound.

INDUSTRIAL PLANTS IN THE CANARY ISLANDS.

The dress of the people is essentially Spanish, the cloak and white mantilla being common. Most of the dress material is imported, though local industry produces coarse linen and woollen fabrics. Flax is grown in small quantities, and the American aloe *(Agave)* affords abundant fibre for ropes and girths. Silkworms are reared in some numbers, and their produce is partly manufactured into ribbons and hosiery, and partly exported raw. Sumach is grown in small quantities for dyeing and tanning. Cacti, especially *Opuntia tuna*, cover a very large area, being grown for the support of the cochineal insect. The dyestuff obtained from this insect has long been one of the chief articles of export, but like madder and the rest of the organic dyewares, it is fading before the competition of the coal-tar colours; the export in 1883-4 was under 2,500,000 lb., value £112,000. Another dyestuff produced very largely on these islands is orchil *(Roccella tinctoria)*, the rocky coast offering a fine habitat for the lichen; the product is chiefly exported; the figures for 1883-4 were 272 cwt., value £641. Hats and other plaited fabrics are made from the fibre of the date leaves. The cultivation of the ice plant *(Mesembryanthemum crystallinum)* is still prosecuted for the sake of the alkali contained in its ashes, exported under the name of barilla, and used in glass making; the shipments in 1883-4 were 6,902 cwt., value £1,102, all to Spain. Tobacco is grown successfully, and is improving in quality; the exports recorded in 1883-4 were 2,292 cwt., value £10,373.

THE TUNNY FISHERY.

The migration of the tunny into Italian waters, appears to have been first observed by Pietro Porta towards the close of the 16th century, and it is from that period, that the fishery of this important article of food may be said to date. It was not, however, until the middle of the 18th century that it had reached a certain importance, on account of the passage of the fish being intercepted by 17 large nets on the Spanish coast. The tunny, it is well-known, makes its appearance in the Mediterranean every spring towards the end of April, and, entering that sea by the Straits of Gibraltar, this fish follows the coasts of Spain and France as far as the Island of Hyères, when leaving the coast it takes a southerly course towards the Island of Sardinia. It appears that, previous to 1755, the year of the great earthquake of Lisbon, the shoals of tunny passed closed to the shore; but, in consequence of a great upheaval of sand which reduced the depth of water to less than 30 metres (depth at which this fish inhabits), the route was deviated from the coast, to the great advantage of the Sardinia fisheries on the one hand, and to the detriment of the Spanish on the other, which in consequence fell into decline. It has been observed that, of late years, the fish are gradually returning to their old route, which is probably due to the action of submarine currents, which have the effect of deepening the shallow places along the coast, and restoring them to their primitive condition; this supposition is strengthened by the fact of the increase in the number of fish taken every year on the Spanish, and of a corresponding falling off in that on the Sardinian coast. The Spanish fisheries have recently been purchased by some enterprising firms of Genoa and Turin, who propose conducting them and preserving the fish caught on a large scale, and in that manner have secured for Italy an almost exclusive monopoly for this industry.

Up to the 4th of June of the present year the number of barrels of tunny landed at the Port of Genoa, amounted to 20,021; whilst the total quantity brought to that port in 1885, did not exceed 18,800. In the production of the present year, 9,539 barrels were brought from Sardinia, 2,484 barrels from Sicily, 3,984 barrels from Spain, and 4,014 barrels from Portugal.

ANIMAL FOODS OF ABYSSINIA.

The Abyssinians are great consumers of meat. This they eat raw, and when guests are invited to a feast, a bullock is slaughtered in an adjoining apartment while they wait, and they are offered slices of the meat still warm from the animal, sometimes even cut off before death has taken place. The manner of eating is to put one end of the strip of flesh into the mouth, holding the other end in the left hand, and to slash off small pieces with a sword or knife moved from left to right just clear of the nose.

Honey is an important product of the country, the Tazma honey, from the province of Abamada, being much esteemed. Large quantities are consumed in making a beverage called *tecc*, for holding which small bottles are imported from Alexandria. Among the ingredients incorporated in this mead, are the astringent and bitter bark of a plant called *heeto*, whose leaves and fruit are narcotic and poisonous; the leaves of a tree named *keesho*; and a root known as *taddo*. Another kind of mead is termed *mese*.

The Abyssinians take very large quantities of milk, but never in a fresh condition. The souring is achieved by placing the fresh milk in dishes which are never cleaned, and thus fermentation is set up without adding any medium. Abyssinian butter is met with at all the ports on the Red Sea, but, on account of the excessive heat, it is in a melted state, and is not a wholesome or tempting article of food.

General Notes.

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Swiss Silk-throwing Industry.—In the year 1885, this trade occupied 7,756 workpeople, of whom 5,520 were in factories, and the remainder at their own homes. The wages paid amounted to about £108,000, and the entire production was 395 tons, thus classified:—Trams 228, sewing silk and cordonnets 90, organzine 64, and embroidery silk 13. About 90 per cent. of the available machinery was employed.

Forests in Hungary.—Some recent statistics show that the area of country covered with forests in Hungary is about 10,000,000 of hectares (nearly 25,000,000 of acres), half of which is covered with beech and other leafy trees, whilst the remainder are principally oaks and pines. Some of the forests belonging to private proprietors are very extensive, and of these may be mentioned the domain of Munkacs, extending over 106,720 hectares; the domain of Arva, 34,530 hectares; and the domain of Malaczka, 28,140 hectares.

PILE DRIVING BY DYNAMITE.—An engineer of Pest, Mr. Pradanovic, has lately used dynamite for driving piles. A circular cast-iron plate, 15 inches in diameter, and 3¾ inches thick, is fixed on the pile to be driven, in a perfectly horizontal position. A dynamite cartridge made in the form of a disc, 6 inches in diameter, and ¾ of an inch thick, and containing 17½ ounces of dynamite, is placed upon the cast-iron plate, and exploded by electricity. It is stated that the depth to which the pile is driven by each explosion is equal to five blows of an ordinary pile engine weighing 14¾ Vienna cwts., falling 9 feet 10 inches. A cast-iron plate on an average resists 25 explosions.

MEXICAN TEXTILE INDUSTRY.—According to official statistics, the cotton crop of Mexico increased from 50,000,000 lbs. in 1879, to 55,000,000 lbs. in 1883. The imports from the United States rose from 20,500,000 lbs. in 1883, to 75,500,000 lbs. in 1884. The principal cotton manufactures are brown shirtings; bleached goods being mostly imported from England or America. There are altogether 88 cotton factories in Mexico, and 7 wool factories. The most important is at Queretaro, and occupies 800 workpeople. The water is conveyed from the mountains by an aqueduct 8 miles in length. There are 15 or 20 cotton printing establishments in Mexico, the largest of which has 5 steam-engines.

TECHNICAL INSTRUCTION IN AUSTRIA.—The total grant for 1886 is about £125,000, as compared with £70,000 in 1883. The principal establishments are the Vienna and Prague Schools of Industrial Art; 13 industrial schools in various parts of the country; the Vienna Textile School, the machinery schools at Klagenfurt and Komotau, and the Lemberg Industrial School. Special institutions also exist for various trades as follows:—Lace and embroidery, 12; weaving and knitting, &c., 28; wood and stone, 27; basket making, 16; fancy hardware, pottery, and glass, 7; metal working, 5. Schools of instruction to the number of 159 are also in existence, which are wholly or partly supported by the State. There are likewise six commercial museums, eight industrial societies, nine commercial schools, and two experimental institutions, respectively for leather and photography.

EMIGRATION FROM ITALY.—According to the latest statistics, a sensible increase may be observed in the emigration from Italy during 1885 as compared with that of the previous year, being 77,029 persons during the former as compared with 58,049 during the latter. On the other hand, a falling off may be observed in the temporary absence from the country, being 88,968 in 1884, against 80,164 in 1885. Of the total number who left Italy last year (157,193) 78,232 persons left for European countries, of whom 33,438 to France, 16,962 to Austria, 10,744 to Hungary, 4,583 to Switzerland, 4,532 to Germany, &c. The emigration to other continents increased considerably last year, being 6,217 to Africa, and 72,490 to America (as compared with 55,467 in 1884), of which 40,054 to the Argentine Republic, 12,311 to Brazil, 937 to Mexico and Central America, and 13,096 to the United States and Canada.

ITALIAN FACTORY STATISTICS.—According to official statistics, it appears that on the 31st December, 1881, 382,131 persons were engaged in manufactories in Italy. Of these 219,844 were spinners (69,447 being children), 77,779 weavers (13,628 children), and in printing 15,499 (618 children) were employed. In 1876 there were 229,538 weavers who worked at their own homes, chiefly in Sicily, Sardinia, Calabria, Apulia, and the Marche of Ancona.

ARTESIAN WELL AT PEST.—The deepest artesian well in the world is that now being bored at Pest, for the purpose of supplying the public baths and other establishments with hot water. A depth of 951 metres (3,120 feet) has already been reached, and it furnishes 800 cubic metres (176,000 gallons) daily, at a temperature of 70° Centigrade (158° Fahr.) The municipality have recently voted a large subvention in order that the boring may be contined to a greater depth, not only to obtain a larger volume of water, but at a temperature of 80° Centigrade (176° Fahr.).

MEETINGS FOR THE ENSUING WEEK.

MONDAY, JUNE 28...Colonial and Indian Exhibition, South Kensington, S.W., 8½ p.m. Joseph Bosisto, President of the Royal Commission of Victoria, "Australian Vegetation, with special reference to the Eucalypti."

TUESDAY, JUNE 29...Colonial and Indian Exhibition, South Kensington, S.W., 4 p.m. Conference of the Anthropological Institute. "Races of New Zealand."

WEDNESDAY, JUNE 30...SOCIETY OF ARTS, John-street, Adelphi, W.C., 4 p.m. Annual Meeting.

Colonial and Indian Exhibition, South Kensington, S.W., 4 p.m. Dr. W. Fream, "Colonial Forestry." 8½ p.m. Major Craigie, "Home, Foreign, and Colonial Sources of Meat Supply."

THURSDAY, JULY 1...Colonial and Indian Exhibition, South Kensington, S.W., 4 p.m. Conference of the Imperial Federation League. "Imperial Federation." 8 p.m. Mr. F. W. Pennefather, "New Zealand as a Field for Emigration."

FRIDAY, JULY 2...Colonial and Indian Exhibition, South Kensington, S.W., 4 p.m. Conference of the Imperial Federation League. 8 p.m. Mr. W. H. P. Greswell, "Advance of Civilisation and Education in Cape Colony."

SATURDAY, JULY 3...Colonial and Indian Exhibition, South Kensington, S.W., 3 p.m. Conference of the Geologists' Association. Dr. A. R. Selwyn, "Canada."

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FRIDAY, JULY 2, 1886.

All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

NOTICES.

CONVERSAZIONE.

The Society of Arts Conversazione will be held, by permission of the Royal Commission, at the Colonial and Indian Exhibition, South Kensington, on Friday, the 16th of July next.

Each member has received a card for himself, which is not transferable, and a card for a lady. In addition to this, cards will be sold to members of the Society, or to persons introduced by a member, at the following prices:—Until the 3rd of July, 7s. each; after that date 10s. each, except on the 16th July, when the price will be 15s.

Members are requested to take notice that all applications received at the Society's offices, whether personal or by letter, after the first post on Monday, July 5th, must be accompanied by a fee of 10s. Tickets applied for personally before 3 p.m. on Saturday, or by letter posted before Monday, will be supplied at the 7s. rate.

The Council reserve the right of stopping the sale of tickets or of raising the price, if it is found necessary, in order to restrict the number of visitors within reasonable limits.

Tickets will only be supplied to persons presenting members' vouchers (forms of which can be obtained from the Secretary), or a letter of introduction from a member.

Members can purchase these additional tickets by personal application, or by letter addressed to the Secretary. In all cases of application by letter, a remittance must be enclosed. Each ticket will admit one person, either lady or gentleman.

Light refreshments (tea, coffee, ices, &c.) will be supplied at the usual buffets. No refreshments can be obtained by purchase.

There will be no admission to the Exhibition on this evening except by special ticket, and no tickets can be purchased at the Exhibition.

Proceedings of the Society.

ANNUAL GENERAL MEETING.

The Annual General Meeting for receiving the report from the Council, and the Treasurers' Statement of Receipts, Payments, and Expenditure during the past year, and also for the Election of Officers, was held, in accordance with the Bye-laws, on Wednesday last, the 30th instant, at four p.m., Sir FREDERICK ABEL, C.B., D.C.L., F.R.S., Chairman of the Council, in the chair.

The SECRETARY read the notice convening the meeting, and the minutes of the previous annual general meeting.

The following candidates were proposed, balloted for, and duly elected members of the Society:—

Anderson, James, 16, Strand-road, Calcutta.
Armstrong, John, Mansion-house-chambers, E.C.
Baden-Powell, Baden Henry, C.I.E., 8, St. George's-place, Hyde-park-corner, S.W.
Bannister, Richard, The Government Laboratory, Somerset-house, W.C.
Begg, Alexander, 83, Cannon-street, E.C.
Bousfield, John Ebenezer, 6, Claremont-road, Cricklewood, N.W.
Boyd, James, The Manor, Harefield, near Uxbridge.
Chubb, Harry W., 128, Queen Victoria-street, E.C.
Clegg, Harry, Plas Llanfair, Llanfair, P.G., Anglesey.
Combes, Edward, C.M.G., New South Wales Court, Colonial and Indian Exhibition, South Kensington, S.W.
Dalton, George, The Yews, Headingley, Leeds.
Dunne, Captain John J., Fly Fishers' Club, 10, Adelphi-terrace, W.C.
Floyer, George Wadham, 37, Old Jewry, E.C.
Garrick, Hon. Sir James F., K.C.M.G., Q.C., 1, Westminster-chambers, S.W.
Gibbs, James, C.S.I., C.I.E., 58, Courtfield-gardens, South Kensington, S.W.
Gittins, Charles Edward, 113, Iverson-road, West Hampstead, N.W.
Gladstone, Lieut. Charles E., R.N., H.M.S. *Vernon*, Portsmouth.
Grewing, Henry, 26, Queen Anne's-gate, S.W.
Grundy, Charles, J.P., Melton-lodge, Havelock-road, Addiscombe.

Gwyther, William Warlow, 43, Lincoln's-inn-fields, W.C., and Reform Club, S.W.
Hockady, John, Essex-house, Peckham-rye, S.E.
Hollick, Thomas Pratt, 26, Shore-road, Hackney, E., and Regent's Canal Dock, 602, Commercial-road East, E.
Lindsay, C.R., Glen Lea, Dulwich-common, S.E.
Lloyd, Robert Hodgens, M.D., Lambeth Infirmary, S.E.
Matthey, Edward, 78, Hatton-garden, E.C.
Purves, George, 8, De Vere-mansions west, De Vere-gardens, Kensington, W.
Slater, Alfred Thomas, 249, Camden-road, N.
Smith, Albert Mervyn, Bangalore, India.
Smith, Dr. L. L., Victoria Commission, Colonial and Indian Exhibition, South Kensington, S.W.
Stevenson, Thomas Graham, Ellingham, Upton-lane, Forest-gate, E.
Vickery, George, 18, Addle-street, E.C.
Vigers, George, 4, Frederick's-place, Old Jewry, E.C.

The CHAIRMAN nominated Mr. P. J. Reid and Mr. T. H. Blakesley, scrutineers, and declared the ballot open.

The SECRETARY then read the following:—

ANNUAL REPORT.

I.—ORDINARY MEETINGS.

The papers read at the Ordinary Meetings of the Society during the past Session have spread over as wide a range of subjects as is usual, and they have certainly not fallen short, either in interest or in intrinsic value, of those which have been brought before the Society in former years. In the address with which, according to custom, the Chairman of Council, Sir Frederick Abel, opened the proceedings of the Session, the main topic dealt with was the prevention of accidents in coal-mines, a subject which, as the members are well aware, has been under the consideration of a Royal Commission for five or six years. Sir Frederick Abel's position, as a member of that Commission, enabled him to bring forcibly before the Society some of the principal points connected with this important question, a question which has since been more fully dealt with in the report of the Commission, published in April last.

Looking at the different classes of papers brought before the Society in the Session just concluded, it may perhaps be said that the most important series was that dealing with questions of mechanical science. The papers which may be thus classed together are those by Captain Galton, on "Tramway Motors;" by Mr. Henry Davey, on "Machinery in Mines;" by Professor Unwin, on "Testing Machinery;" by Mr. Boys, on "Calculating Machines;" by Professor Waldo, on "Watch Making by Machinery;" and by Professor Silvanus Thompson, on "The Automatic Extinction of Fires." All of these were of a very high order of merit, three of them having been considered by the Council as deserving the recognition of the Society's silver medal; Captain Galton's paper, as the work of a member of the Council, was not eligible for such an award. The Society are especially indebted to Professor Waldo, who came over from America for the purpose of bringing before the notice of the Society the very great improvements effected in the application of machinery to the manufacture of watches, a subject to which special attention was attracted last year by the very fine collection of machinery for this purpose shown by the American Waltham Watch Company at the Inventions Exhibition.

Two papers dealt with the progress of electric lighting—a subject which has been very prominently before the members of the Society in papers read during the past few Sessions, but one which seems nevertheless to have lost none of its interest. These papers were by Professor Forbes, on "Electrical Distribution," and by Mr. Preece—a member of Council to whom the Society owes very much for his lectures and papers—on "Domestic Electric Lighting." Another paper dealing with one important application of electricity was that of Mr. Price Edwards, who gave the Society an account of the experiments which had been made by the Trinity House at the South Foreland to test the merits of the three systems of lighthouse illumination, by oil, by gas, and by electricity.

Papers dealing with artistic matters were those by Mr. Hulme, on "Technical Art Teaching;" by Mr. George Simonds, on "Bronze Casting;" by Mr. Vincent Robinson, on "Eastern Carpets;" by Mr. Hodson, on the "Photographic Reproduction of Drawings;" and by Mr. Ablett, on "Museums for Trade Patterns." It will thus be seen that the papers dealing with the applications of the fine arts have been slightly more numerous in this Session than in some preceding ones. Dr. Meymott Tidy gave a comprehensive review of the progress which has been made with methods of dealing with sewage. Though a second evening was allotted for the discussion of the paper (which owing to its length, and to the fact that it was not complete, was delivered in abstract by its author), this did not suffice to give an opportunity to all who wished to take up some of the many points raised by Dr. Tidy, and the Council have therefore determined to arrange for the renewal of the discussion next Session, by which time they hope that Dr. Tidy will have furnished the Society with the full text of the paper. Mr. Willis-Bund, by a paper on the "Proposed Fishery Department," gave the Society an opportunity of discussing the proposals now before the country for the protection and development of the fishing industry. Dr. Armitage, whose devotion to the cause of the blind is well known, supplemented the paper he read years ago on the "Education of the Blind," with one in which he gave an account of the successful carrying into effect of the proposals he then made. Mr. Brough's paper on "Mining Industry at the Buda-Pest Exhibition," is an important contribution to the statistics of mining industry. Professor Elgar, in his paper on the "Load-line of Ships," brought before the Society the main points of the report on this subject then recently issued; and Mr. Holt Hallett, in his paper on "Burmah," made some useful contributions to our knowledge of that country.

II.—INDIAN SECTION.

Unlike last year, when the number of papers read was eight, the evenings devoted to the Indian Section were only six; in variety of interest and merit of execution the papers were, however, quite equal to those of any previous Session, while the average attendance showed an increase. The Session began on January 22nd, with the very appropriate subject — considering the recent annexation of the country—of "Burma: The Eastern Country and the Race of the Brahmas." The reader of the paper, Mr. J. George Scott, better known as "Shway Yoe," contributed a most graphic and detailed account of the life and social customs of the people with whose habits, as the Chairman, Sir Ashley Eden, observed, no one possessed greater familiarity than the lecturer. The paper formed the substance of Mr. Scott's subsequent book on Burmah, which has been very favourably received by the public and the press, and it is pertinent to state that Mr. Scott was, very shortly after his lecture, sent to Burmah as Assistant Commissioner, to aid in governing the country he had described so well. The second paper, contributed by Mr. F. C. Danvers, Registrar and Keeper of Records at the India-office, dealt with the subject of "Historical and Recent Famines in India." Mr. Danvers' statement, based on official documents, provides an accurate and easily accessible list of the chief occasions on which considerable parts of India have suffered from dearth. The paper by Mr. William Simpson, on his "Experiences on the Afghan Frontier" gave most picturesque details connected with the residence of the English Commission in Badghis, and on the banks of the Murghab. The chair, on this occasion, was occupied by Sir Peter Lumsden, G.C.B., who made some very interesting remarks in connection with the archæological and non-political side of the subject. The fourth meeting was devoted to a paper on the "History of Archæology in India," by Mr. James Gibbs, C.S.I., C.I.E., which provides an exhaustive *résumé* of the labours of such men as the Cunninghams, Major Keith, and others. The fifth paper, on "Indian Manufactures from a Practical Point of View," read by Mr. B. Baden Powell, C.I.E., affords a useful piece of criticism on some of the functions and practical objects of the Colonial and Indian Exhibition. The sixth and last paper of the Section, and, in some respects, the most attractive of the whole series, was by Captain Richard Carnac Temple, the subject being "The Everyday Life of Indian Women;" a very carefully worked out and most interesting description of our Indian sisters was therein given.

III.—FOREIGN AND COLONIAL SECTION.

The work of the Foreign and Colonial Section of the Society has been very well maintained this year. Seven valuable papers have been read. At the opening of the Session Mr. Arnold White put before the Society his views of the "Importance of a National Scheme of Emigration for the Advancement of the Interests of British Commerce," and argued for the establishment of a national council for raising and distributing funds, and for securing information as to the particular needs and capacities for absorption of the various colonies. The Secretary of the Section, Dr. Mann, communicated a sketch of the present state of Colonial dependencies, at this time comprising, inclusive of India, an area of about 8,900,000 square miles, and a population of about 315,000,000, with a trade of the annual value of about

£390,000,000 sterling. Mr. John Mackenzie, late Deputy Commissioner of Bechuanaland, filled a vacancy caused by the unavoidable absence of Sir Charles Warren, who had undertaken a contribution on Bechuanaland, by a very interesting account of the condition and prospects of this promising district of South Africa, in reference to which he contends that Great Britain has a great task and a noble work to perform. Mr. Alexander Begg, under the presidency of Sir Charles Tupper, the High Commissioner for Canada, gave a very interesting account of the successful completion of the National Highway of Canada, the Canadian Pacific Railway, in which not less than 961 miles of road were constructed in three years, and describes the revolution which has been effected in the prospects of the colony by the accomplishment of this gigantic enterprise. Mr. P. L. Simmonds, in reference to the work of the Colonial and Indian Exhibition at South Kensington, traced the material progress in the various branches of productive and pastoral industry made by the British Possessions during the lapse of a quarter of a century, during which the number of steam vessels employed in British trade has been trebled, and the number of tons which they are capable of transporting across the ocean has been augmented sevenfold. Mr. Edward Combes, gave an exhaustive history of the commerce and industries of New South Wales, a district comprising a tenth part of the area of the Australian mainland; in which the number of sheep have increased in twenty-two years from 6,000,000 to 34,000,000, the annual production of wool, at the present time, amounting to a value exceeding £9,000,000 sterling, and in which the coal-producing area is estimated at six times that of the British Isles. At the last meeting of the Session, Mr. G. Gordon Hake gave an account of the progress made by Cyprus since the island was occupied by Great Britain; the foreign trade was shown to have exactly doubled in the period, while the annual value of the export of wine had increased from £25,000 to £45,000, locusts having been gradually exterminated under the measures adopted by the Government. An interesting discussion took place on the bearing of the tribute upon the industrial capacities of the island, upon the fostering of forest-growth, upon the improvement of the port, and the construction of railways. Sir Robert Biddulph (who presided) urged that all effort should be directed to capitalising the charge of the revenue, rather than abolishing it, by the purchase outright of the possession of the island.

The members of the Society will learn with regret that Dr. R. J. Mann, who has been since 1874 the able and indefatigable Secretary of this Section, has been compelled, by the state of his health, to resign his post. The Council submit his name to the Society for election upon the Council, so that he may still be enabled to assist in the management of the Section, even if he can no longer undertake the constant and rather arduous duties attaching to the secretaryship of the Section.

IV.—SECTION OF APPLIED CHEMISTRY AND PHYSICS.

The Section of the Society devoted to papers on Applied Physics and Chemistry has this year had several papers of a very high order. The first, on the "Magnetism of Ships and the Mariner's Compass," was given by Mr. William Bottomley, of the University of Glasgow, who has been engaged for some time with Sir William Thomson in improving ships' compasses; it presents in a convenient and condensed form, the more important matters connected with such recent improvements. The second paper was by Professor Hartley, F.R.S., of Dublin, on "Photography and the Spectroscope in their Application to Chemical Analysis," for which one of the Medals of the Society has been awarded. Professor Hartley gives a summary of the work done in recent years on the relations existing between the chemical constitution and the absorption spectra of substances, and on the application of such relations to analytical processes. In the paper the greatest stress is laid upon the relations existing between organic substances, but the application of the methods to mineral analysis are also treated of. The apparatus employed, which has been most carefully elaborated by Professor Hartley within the last few years, is fully described in the paper.

Following Professor Hartley's paper, one on "Films and Paper as Substitutes for Glass in Photography" was given by Mr. Leon Warnerke, whose name is well known in connection with this recent improvement in photography. Mr. Warnerke traced the development of what may be termed film photography, and described the progress made in the apparatus destined to hold the film in position, either by fixed squares of wood or roller slides. The paper is a valuable addition to photographic literature, coming as it does at a time when light paper films are tending to supersede the heavy glass plate for those who wish to do work while travelling.

In the fourth paper contributed to the Section, "On some Appliances for the Utilisation of Refuse and Dust Fuel," Mr. McMillan, of King's College, describes the recent improvements in this direction, paying special attention to the furnaces devised by Mr. T. R. Crampton, and to Perret's furnace, specially constructed for the combustion of dust fuel. The paper contains a condensed description of the various furnaces employed, and is extremely suitable for reference.

In the fifth paper, Mr. Boyd, of the United Asbestos Company, gave a description of the various forms of asbestos now found in Italy and Canada, and an account of its many practical applications, such as the packing for steam-engines; its employment in the larger guns now used by the artillery as an efficient means of closing the breach of the gun; and its conversion into cloth, millboard, and tubing.

The Section closed by a most important paper by Prof. Meldola, of the City and Guilds Technical College, Finsbury, on the "Scientific Development of the Coal-Tar Colour Industry," in which Prof. Meldola describes the foundation of the industry by Perkin, in 1856, by the discovery of mauve, and the rise of the industry in this country; he finally points out the danger of its decline in England, urging, as a means for the stoppage of such a decline, a proper recognition of the teaching of technical, that is, applied science, throughout the country.

Considering the many societies which now exist throughout the country, whose object it is to collect and publish papers upon chemistry and physics as applied to the arts and manufactures, the Society is to be congratulated on having brought forward a series of papers in this Section of so much importance.

V.—CANTOR LECTURES.

The six courses of Cantor lectures which have been delivered during the past Session were, in accordance with the usual practice of the Council, arranged to deal with as many different topics as possible, with the view of meeting the diversified requirements of so numerous and variously constituted a Society as the Society of Arts. The course before Christmas was by Mr. Mayall, on "The Microscope." It dealt with the history of the instrument, and the various improvements in its mechanical construction which have been introduced up to the present time. Additional value was lent to this course from the fact that Mr. Mayall was enabled to illustrate it from the magnificent collection of microscopes possessed by Mr. Crisp, which was not only shown at the lectures themselves, but was left for examination during the time over which the course extended. Professor Hele Shaw followed with a valuable course on "Friction," a subject to which he has been devoting special attention for some time past. In the third course Professor Guthrie brought before the Society suggestions, based upon his long experience, for the improvement of our methods of teaching science. The next course was by Mr. Boverton Redwood, the Secretary of the Petroleum Association, on "Petroleum and its Products." This, like Mr. Mayall's course, had the advantage of being very fully illustrated with apparatus for the treatment, examination, and burning of petroleum, and with specimens of all the products obtained in the manufacture. Mr. Alan S. Cole, whose lectures in April, 1881, on "Lace-making" have had a very important result in the improvement of that industry in Ireland, gave a short course on a similar subject, "The Arts of Tapestry Making and Embroidery." The last course of the Session was one by Dr. Richardson on "Animal Mechanics."

VI.—JUVENILE LECTURES.

The Juvenile Lectures for the Session were delivered by Professor Silvanus Thompson, the subject being "Waves." In his first lecture sound waves were treated, and in the second waves of light and electricity. Both lectures were very fully illustrated with experiments, and attracted large and attentive audiences. The usual system was adopted of issuing special tickets for these lectures, and it, as has been the case before, was found to work extremely well, none of the members who applied in reasonable time having been disappointed.

VII.—ALBERT MEDAL.

The Albert Medal for the present year was (with the approval of the President, H.R.H. the Prince of Wales) awarded by the Council to Mr. Samuel Cunliffe Lister, "for the services he has rendered to the textile industries, especially by the substitution of mechanical wool-combing, and by the introduction and development of a new industry—the utilisation of waste silk."

The Council have been enabled to recognise for the first time services rendered to the textile manufactures, by making this award to one who may fairly be said to have done more than any other man of the present generation to promote the advance of this most important branch of British commerce.

Though the inventions of Mr. Lister are well known to all textile manufacturers, it may yet be interesting to place them briefly on record here:—In 1847, he was engaged in introducing a wool-combing machine into England and France for fine wool. In 1850 he, jointly with the late Mr. Donisthorpe, invented the only wool-combing machine which could comb all kinds of wool. So important was this invention that, although the cost of a single machine was only some £300 or £400, it commanded a royalty of £1,000. After years of opposition, Mr. Lister's fellow-townsmen of Bradford have acknowledged him as a public benefactor, and have erected a statue to him him in their Town-hall. He embarked the whole of the fortune realised by wool-combing, in the utilisation of silk waste, that is, the waste and refuse made in winding silk from the cocoons. He invented machines for combing this waste silk and making it up into yarn; and then—and this was perhaps the most important of all his achievements—he introduced and perfected velvet looms, by which velvets are now produced in this country by machinery. This has, for the second time, given a new industry to the country and to Bradford in particular. Mr. Lister's works at Manningham, for the utilisation of this previously waste material, cover eleven acres, and are the largest in the kingdom, not excluding even those of the late Sir Titus Salt; they give employment to some 4,000 workmen. The annual value of the exports of velvet from these works is reckoned in hundreds of thousands of pounds, which is all created out of what is called, even to this day, "silk waste."

VIII.—MEDALS.

In accordance with the usual practice the Council have awarded silver medals for certain papers read at the ordinary meetings, and at the meetings of the three Sections, the number (twelve in all) being slightly in excess of the average of recent years. Of these medals five have been given for papers read at the Ordinary Meetings, three for papers in the Foreign and Colonial Section, two for papers in the Section of Applied Chemistry and Physics, and two for papers in the Indian Section. Besides the papers which received this compliment, there have been two the merits of which, as they were the work of members of their own body, the Council are, by their invariable custom, precluded from recognising otherwise than by a vote of thanks. These papers are—

By CAPT. DOUGLAS GALTON, D.C.L., C.B., F.R.S., on "Results of Experiments on Mechanical Motors for Tramways made by the Commission at the Antwerp Exhibition."

By W. H. PREECE, F.R.S., on "Domestic Electric Lighting."

The following is the complete list of the awards of the medals:—

To PROF. FRANCIS ELGAR, LL.D., for his paper on "The Loadlines of Ships."

To HENRY DAVEY, for his paper on "Machinery in Mines."

To PROF. W. C. UNWIN, for his paper on "The Employment of Autographic Records in Testing Materials."

To C. V. BOYS, for his paper on "Calculating Machines."

To PROF. LEONARD WALDO, D.Sc., for his paper on "Watch-making by Machinery."

To JOHN MACKENZIE, for his paper on "Bechuanaland and Austral Africa."

To EDWARD COMBES, C.M.G., for his paper on "The Industries and Commerce of New South Wales."

To G. GORDON HAKE, for his paper on "Cyprus since the British Occupation."

To PROF. W. N. HARTLEY, F.R.S., for his paper on "Photography and the Spectroscope in their Application to Chemical Analysis."

To PROF. R. MELDOLA, for his paper on "The Scientific Development of the Coal Tar Colour Industry."

To B. H. BADEN POWELL, C.I.E., for his paper on "Indian Manufactures from a Practical Point of View."

To CAPT. RICHARD CARNAC TEMPLE, for his paper on "Everyday Life of Indian Women."

IX.—ADDITIONAL LECTURES.

Besides the usual courses of Cantor Lectures, there have been this Session two additional courses of lectures. Mr. Ernest Hart gave a short but very interesting course on "Japanese Art-Work" on three Tuesday evenings in May; and Professor George Forbes delivered a course of six elementary lectures on "Electricity," on Saturday afternoons, in April and May. Mr. Ernest Hart's course was illustrated by the exhibition of his collection of Japanese articles, believed to be the finest in existence, which was on view in the library during the time of the delivery of the lectures; it was visited by more than 1,000 persons, and attracted a great deal of public attention. The Council are very much indebted to Mr. Hart both for the lectures and for the opportunity he afforded to the members of the Society and to their friends of inspecting this most interesting collection. Professor Forbes's lectures were, in accordance with the wishes of the Council, of an elementary nature, it being thought that many members of the Society who had not given special attention to the study of electricity would be glad to receive a certain amount of general information upon it. The experiment of giving a course of afternoon lectures must be considered to have been successful, as the audience was always a large one.

The regulations for admission to these additional courses of lectures were the same as for the Cantor Lectures, every member having the right of admitting a friend, in addition to his right to attend personally.

X.—OWEN JONES PRIZES.

These prizes are awarded on the results of the annual competition of the Science and Art Department to students of the Schools of Art, who produce the best designs for household furniture, &c., on the principles laid down by Owen Jones. Six prizes were offered for competition last year, each prize consisting of a bound copy of Owen Jones's "Principles of Design" and a Bronze Medal. A list of the successful candidates has appeared in the *Journal*.* A similar number of prizes has been offered for the present year (1885-6), and the result of the competition will be published in the *Journal* as soon as the results have been received from the Science and Art Department.

XI.—WESTGARTH PRIZE ESSAYS.

The three essays to which prizes of £100 were awarded have been published in a volume, which is illustrated by reproductions of the principal plans submitted by the essayists with their essays. A number of copies have been presented by the Council to various public libraries.

XII.—INTERNATIONAL INVENTIONS EXHIBITION MEDALS.

It was announced in the last report of the Council that ten gold medals had been offered on behalf of the Society to exhibitors at the International Inventions Exhibition, to be awarded by the Council on the recommendation of the Juries of the Exhibition. Eight of these medals were duly awarded, five in the Inventions Division and three in the Music Division. Lists of the recipients appeared in the *Journal*.*

In addition to the five medals offered in Division I.—Inventions—the Council, at the special request of the Council of the Exhibition, awarded additional gold medals to Sir Henry Bessemer, Mr. Percy Gilchrist, and the Badische Anilin und Soda Fabrik. In making the request, the authorities of the Exhibition expressed their readiness to discharge the cost of these three additional medals, but the Council considered that they were justified in letting this additional charge fall upon the funds of the Society, feeling sure that it would be more agreeable to the members that the Society should be at the cost of the medals awarded in its name. The income from Trust Funds available for such purposes was sufficient to discharge the cost of all the medals.

XIII.—INTERNATIONAL INVENTIONS EXHIBITION.

The accommodation offered by the Society to the meetings of the Executive Council, the Jury Commission, and the various Committees of the Inventions Exhibition, referred to in the last Annual Report, was continued during the holding of the Exhibition and after its close. The meetings of the Executive Council were held in the Exhibition itself, while it was open, but the few meetings held since that time have been at the Society. The Jury Commission also held many of their meetings here. Reports on most of the principal sections of the Exhibition have appeared in the columns of the *Journal*.

XIV.—COLONIAL AND INDIAN EXHIBITION.

The Council have also co-operated with the Royal Commission appointed to carry into effect H.R.H. the Prince of Wales's suggestion for the holding of a Colonial and Indian Exhibition this year. As there was no Executive Council for this Exhibition, the necessity did not arise for office accommodation, as had been the case with its two predecessors;

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* See *Journal*, vol. xxxiii, p. 961.

* The awards in Division I.—Inventions—were given in the *Journal* for August 14, 1885, p. 949; and the awards for Division II.—Music—were given in the *Journal* for November 13, 1885, p. 1131.

the first meeting of the Reception Committee, however, and of the Committee for arranging the Conferences at the Exhibition, were held at the Society of Arts. The *Journal* serves, as in former instances, as the official organ of the Exhibition, and a very full record of the growth and progress of the Exhibition up to the present time will be found in its pages. In succeeding numbers of the *Journal* it is proposed, as far as space may permit, to give some account of the different classes of productions exhibited. The Council have also undertaken to superintend for the Royal Commission the publication of the Reports announced for preparation upon its Colonial Sections, and they have now under consideration the arrangements necessary for carrying this proposal into effect.

The Council are gratified to learn that a movement is on foot for the foundation of a Colonial Museum, and they trust that this important project, which has in past years been several times under the notice of the Society, may at last be carried to a successful issue.

XV.—CONVERSAZIONE, 1885.

The arrangements which were made for holding the Conversazione last year were detailed in the last Annual Report, and in the *Journal** the holding of the Conversazione was reported. It may, however, be interesting to record here that the financial arrangement made with the Executive Council of the Inventions Exhibition fully bore out the expectations expressed in last year's report, the cost to the Society only amounting to £300, a sum which is about the average of recent years. There were in all 10,652 persons present; the amount received from the sale of tickets was £1,543 17s. 6d.; the amount expended on refreshments, bands, printing, &c., was £1,308 16s. 11d., leaving a balance of £234 0s. 7d., which, together with the sum of £300 agreed to be paid by the Society, was handed over to the Exhibition. Out of this sum of £534, the cost of the electric lighting and attendance had also to be defrayed by the Exhibition Executive. Setting this amount against the charges to be paid by the Exhibition, and the loss from the diminution of receipts caused by the closing of the Exhibition for the evening, it was proved that the Exhibition itself incurred no pecuniary loss whatever by the loan of its buildings to the Society. The Exhibition Executive were therefore enabled to gratify the members of the Society and their friends without any diminution of their receipts, and the Society had the benefit of a most interesting and attractive *fête* without being called upon to pay more than the ordinary charges for the annual Conversazione.

XVI.—CONVERSAZIONE, 1886.

The financial success which attended last year's Conversazione justified the Council in applying to the Royal Commission that the favour extended to the Society last year by the Council of the Inventions Exhibition might be repeated this year, and H.R.H. the Prince of Wales, the Executive President of the Commission, on his being satisfied that there was no reason to believe that the Exhibition would suffer any loss of revenue, graciously gave the permission asked for, and placed the Exhibition buildings at the disposal of the Society on the evening of Friday, the 16th July next.

The method tried last year, has, therefore, been again resorted to, that is to say, members of the Society have been permitted to purchase additional tickets for the use of their friends, at prices calculated to cover the probable cost of the evening. The principle of a sliding scale of prices, according to the date at which tickets are purchased, has also been again adopted, as this plan enables the numbers likely to be present to be calculated with approximate accuracy some little time beforehand, and arrangements to be made accordingly. The precise terms on which tickets can be procured have been announced in the *Journal*.*

It may be worth mentioning that the admissions will be restricted to members of the Society, holders of tickets purchased by members, and persons specially invited by the Council on behalf of the Society in accordance with the usual practice.

The Council feel that the members of the Society are greatly indebted to H.R.H. the Executive President of the Exhibition and to the Royal Commission for the privilege of using the Exhibition buildings.

XVII.—EXAMINATIONS.

The Council observe with regret that though the number of centres at which examinations have been held has increased, there has been a slight falling off in the number of candidates examined. Last year, 1,208 presented themselves at 44 centres; and this year only 1,184 entered, at 50 centres. This diminution is the less accountable because there has been a steady growth in numbers since 1882, the year in which the system of examinations was modified, and a fee for the first time charged. Thus, in 1884, 991 were examined at 31 centres; while in 1883 there were 808 candidates, and 35 centres. It may, however, be hoped that the falling off is only temporary, and that next year there may again be an increase. It is improbable, on the other hand, that very large numbers will ever be entered for the Society's examinations, since the Society has no funds to devote to the payment of fees to teachers, with a view to induce them to form special classes, as is done in connection with the Science and Art Department examinations, and with those of the City and Guilds Technical Institute. It must always be remembered that students have no inducement to enter for the Society's examination except the hope of gaining a certificate; and that teachers have no inducement to prepare pupils beyond the credit which their pupils' success reflects upon them.

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* *Journal* for July 10, 1885.

* See *Journal* of May 21st, and following numbers.

Of the 1,184 candidates who entered 943 passed, and 241 failed; the per-centage of successes being slightly higher than last year, when 953 passed and 255 failed. The number of papers worked was 1,274; of these, 116 took first-class certificates, 451 second-class, and 433 third-class, while to 274 papers no certificate was awarded. Nine of the twelve subjects set down for examination were taken up. In three (Italian, Political Economy, and Commercial Geography), no examination was held, as the requisite number of candidates (25) did not present themselves. The number of papers worked in the various subjects were:—Arithmetic, 186; English (including composition and correspondence and précis writing), 100; Book-keeping, 309; Shorthand, 255; French, 112; German, 40; Spanish, 20; Domestic Economy, 58; Theory of Music, 194. In Spanish, the stipulated number (25) of candidates entered, but only 20 came up. The per-centage of failures in Shorthand, though large (96 out of 255) is decreasing, which is satisfactory. In Arithmetic the per-centage of failures is large (85 out of 186). Though the total number of candidates was less than last year, five of the subjects show an increase in the number, presenting themselves, the principal falling off being in Theory of Music, which appears very much less popular this year than last year, when 243 candidates entered. The difference, it will be seen, is more than sufficient to account for the difference in the totals of the two years. It is satisfactory to note a respectable increase in the entries for German. This year there were 40, against 28 last year and none (not enough for examination) in 1884. There is still a slight falling off in English, in Book-keeping (still the most popular subject), and in Spanish. All the remaining subjects show an increase.

In the general scheme of the Examination there was, as compared with that of 1885, only one change of any importance—the omission of the subject of Sanitary Knowledge, in consequence of the Science and Art Department now holding an examination in "Hygiene." This change was made in accordance with an announcement given two years ago that this examination would be discontinued after last year. The Council do not propose to make any alterations of importance in the programme for 1887, which will be issued very shortly.

XVIII.—Practical Music Examinations.

Examinations in practical music have this year been held at the London centre only. There were 152 candidates, of whom 140 passed, taking 56 first class, and 99 second class certificates, with two second class honours. It should be stated that many of the candidates were examined both in the pianoforte and singing, and consequently the number of certificates awarded does not agree with the total number of candidates passing. A comparison with previous years shows that though there is a slight falling off in the number of candidates presenting themselves, the quality is improved, the per-centage of first class certificates being higher than the average of recent years. The examinations was both vocal and instrumental, the instruments taken up by the candidates including the piano, organ, and violin.

XIX.—Electric Lighting Bills.

During the Session three Bills have been introduced in the House of Lords for the amendment of the Electric Lighting Act, 1882. The first of these was brought in by Lord Rayleigh, and had been prepared by a committee, of which Lord Thurlow was chairman. It proposed to put electric lighting companies on the same footing as gas companies, by providing a sliding scale under which the amount of dividend would be regulated by the price of the electricity supplied, the amount of capital on which dividend could be declared being also regulated by an auction clause similar to that now introduced into Gas Companies' Acts. The second Bill was brought in by Lord Bury, and merely proposed to modify the existing Act by lengthening the period before the compulsory purchase clauses would come into operation. The third Bill was brought in some short time after by Lord Houghton on behalf of the Government, and its principal provisions also only went to the extent of increasing the term prior to the option of compulsory purchase arising.

The Council, after full discussion, came to the conclusion that Lord Rayleigh's Bill would, if passed into law, remove at all events the legislative difficulties which now stand in the way of electric lighting, and that it would, at the same time, preserve the interests of the public by protecting them from anything like an injurious monopoly. They also decided that the Government Bill would be but a slight improvement on the existing law, and that as it would not provide sufficient security of tenure to attract capital into electric lighting undertakings, there would be no advantage in its passing, while it would, if passed, certainly hinder any more effective reform. They, therefore, presented a petition to the House of Lords in favour of the former measure,* and another, about three weeks afterwards, against the latter one.† Both petitions were presented on behalf of the Society by the Duke of Abercorn, one of the Society's Vice-Presidents. The three Bills were referred to a Select Committee of the House of Lords, who took some evidence. A majority of this Committee decided in favour of the Government Bill, but refused the insertion of certain clauses, proposed by Lord Houghton, which practically gave unlimited power to the Board of Trade.

When the matter came before the House of Lords again, Lord Houghton withdrew the Government Bill. The Committee had rejected the two other Bills, and thus the Act of 1882 remains in full force, and the distribution of electricity from a central source is still practically prohibited in the United Kingdom.

XX.—MUSICAL PITCH.

It was brought before the notice of the Council that the existence of the pitch known as the Society of Arts' pitch—(C = 528 vibrations)—was an obstacle in the way of those who were endeavouring to secure the adoption of a uniform musical pitch, and the Council therefore appointed a committee to consider and report whether or not it would be desirable for the Society formally to abandon that pitch, and to use its influence to secure the adoption of the French pitch or *diapason normal*—(A = 435, or C = 517·3)—a pitch it will be noted differing but slightly from that recommended by the Society of Arts' Committee in 1860. The question was carefully considered by the Committee, and in accordance with their recommendation, announcement was made that the pitch known by the name of the Society should be abandoned, and that the influence of the Society should be employed in furthering the adoption of the French Pitch. The reasons which led to this decision will be found in the Committee's report, which was printed in the *Journal.** The Committee was, therefore, asked to consider whether any active steps should be taken to secure uniformity of pitch at present. In order to ascertain the state of public feeling in the matter, between 1,800 and 1,900 circulars were issued to members of the musical profession and others interested in the matter. Of the answers received, about 630 were in favour of the adoption of the French pitch, while 80 recommended the adoption of other pitches; all were in favour of uniformity. It thus appeared that a large proportion of those of whom the inquiry was made did not take sufficient interest in the matter to return the form, but that of those who did, a considerable majority was in favour of the French pitch. It is still under consideration whether any active steps in the matter should be taken by the Society. The Council are by no means anxious to move unless it seems probable that the action of the Society will be effectual, and that the question will be settled once for all. It will be recollected that a little time ago application was made to the Duke of Cambridge, recommending the change of pitch in the case of the military bands; but the answer was given that the War-office authorities were not prepared to sanction the expenditure necessary. It has been assumed that, as many of the wind instrument players in concert orchestras are drawn from military bands, this would be an obstacle to the change in the former; but the Council believe this difficulty has been much overrated. For if the transferred players found that their engagements were jeopardised, or that they were exposed to competition with civilian artists, they would, no doubt, soon be induced to provide themselves with duplicate instruments, and in that case it would matter very little at what pitch the military bands might choose to play. In the meantime the change to the French pitch seems to be gradually effecting itself by the volition of the musical public generally; whenever singers can free themselves from the trammels of the regulation orchestra, they adopt the French pitch. Church and cathedral organs (where not wanted to be used with an orchestra) are now, it is believed, generally tuned to this pitch, as are also the great bulk of pianos sent out for domestic use throughout the country; and it seems likely that as the movement extends in other countries, public opinion here will resent the idea that England should partially differ from the rest of the musical world, and that the way will thus be prepared for a formal and general acceptance of the new system. The Council will, at all events, continue to collect information on the subject; they will, moreover, watch the course of events, and, if opportunity occurs, use the influence of the Society to secure the adoption of a reform which seems to have a large majority of educated musical opinion upon its side.

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* See *Journal*, April 2nd, 1886, p. 511.

† See *Journal*, April 16th, 1886, p. 581.

* See *Journal* for February 12, 1886, vol. xxxiv, p. 265.

XXI.—MEMORIAL TABLETS.

Since the last announcement, Tablets have been set up to mark the residences once occupied in London by the following distinguished persons:—

George Cruikshank ....263, Hampstead-road.
Madame D'Arblay (Fanny Burney)....11, Bolton-street, Piccadilly.
Charles Dickens ....Furnival's-inn.
Thomas Gainsborough ....Schomberg-house (now part of the War-office), Pall-mall.

The following is a list of the tablets previously set up:—

James Barry ....36, Castle-street, Oxford-street.
Edmund Burke ....37, Gerrard-street, Soho.
Lord Byron ....16, Holles-street.
George Canning ....37, Conduit-street.
John Dryden ....43, Gerrard-street.
Michael Faraday ....2, Blandford-street, Portman-square.
John Flaxman ....7, Buckingham-street, Fitzroy-square.
Benjamin Franklin ....7, Craven-street, Strand.
David Garrick ....5, Adelphi-terrace.
George Frederick Handel ..25, Brook-street.
William Hogarth ....30, Leicester-square.
Samuel Johnson ....17, Gough-square, Fleet-street.
Napoleon III. ....3A, King-street, St. James's.
Lord Nelson ....147, New Bond-street.
Sir Isaac Newton..........35, St. Martin's-street.
Peter the Great............15, Buckingham-street, Strand.
Sir Joshua Reynolds ......47, Leicester-square.
Richard Brinsley Sheridan..14, Savile-row.
Mrs. Siddons..............27, Upper Baker-street.
Sir Robert Walpole ....5, Arlington-street.

The Council will be glad to receive suggestions from members of the Society or others who know of houses once the residences of celebrated persons, the owners of which would permit the erection of tablets.

XXII.—NEW COUNCIL.

The Vice-Presidents retiring this year are—Sir George Birdwood, the Duke of Buckingham and Chandos, Mr. Cassels, Sir Philip Cunliffe-Owen, and Lord Granville. In their place the Council propose to the Society for election Mr. Alfred Carpmael, Mr. T. R. Crampton, Colonel Donnelly, the Duke of Manchester, and Mr. John Walter. The first two gentlemen have served since 1882 as ordinary members of Council. The other two members of Council retiring are Mr. Vicat Cole, and Mr. J. M. Maclean. To fill the vacancies thus created, the Council propose for election Mr. W. H. Barlow, the eminent engineer; Mr. Henry Doulton; Sir Saul Samuel, the Agent-General for New South Wales; and Dr. R. J. Mann, who has been for the past ten years Secretary of the Foreign and Colonial Section.

XXIII.—LIST OF MEMBERS.

The total number of life members, subscribing members, and institutions in union which subscribe to the Society from their own funds, is now 3,657, or 1 more than at the corresponding period last year, when the number was 3,656. During the year 1885-6, 303 members have been removed from the list by death or resignation. During the same period, 304 have been elected.

XXIV.—OBITUARY.

The losses to the Society by death have not been so heavy this year as often happens. Amongst those who have passed away may be mentioned Lord Shaftesbury; Dr. W. B. Carpenter, who on many occasions rendered valuable help to the Society; Mr. Edward Solly, many years ago its Secretary; Sir

William Rose Robinson, a constant attendant at the meetings of the Indian Section; Mr. Cornelius Walford, who contributed many papers on statistical subjects; Mr. Walter Weldon, the well known technical chemist; and several others, of whom short obituary notices have appeared in the columns of the *Journal*.

XXV.—FINANCE.

It is very satisfactory to notice that, in a time of such general depression as the present, the Society's finances do not show any sign of decreasing prosperity. The amount of annual subscriptions is higher than that of last year, viz., £6,500 against £6,474. The life compositions are, however, less; so that the total amount received from members is nearly £50 less than last year, though exceeding that of any previous year. The gross receipts of the Society from all sources amount to £13,450. Deducting from this amount the items for the Westgarth Prizes, and the sale of Conversazione tickets, which are not ordinary revenue, the total amounts to £10,700, the corresponding total last year being £10,094. The ordinary items of expenditure do not vary greatly from those of previous years. The apparently heavy outlay on the Conversazione, £1,850, is of course partly balanced by the sale of tickets to the amount of £1,550. That the cost of the *Journal* is heavier than usual is accounted for by the fact that it has been necessary somewhat to increase the number of pages in many of the numbers in order to find room for the increasing number of papers and lectures delivered before the Society. During the last summer recess the size of each number of the *Journal* was almost the same as that of the numbers usually published during the Session. The Council believe that the members fully appreciate any additional outlay on this most important department of the Society's work.

A word or two of explanation about the amount appearing under the head of the Westgarth Prizes may be desirable. The total amount—£1,225—was made up of the following items:—Prizes, £600; publication of the prize essays, £225; balance returned to Mr. Westgarth, £400.

The liabilities of the Society are rather less then last year, and the assets considerably more; the excess of assets over liabilities is now £13,092; the corresponding amount last year was £11,581.

Mr. J. Oldfield Chadwick, the Society's auditor, having been compelled by the state of his health to leave England for a short holiday, the account of receipts and expenditure, published in the *Journal*, was audited and signed on his behalf by his son, Mr. Andrew Chadwick, who was appointed by the Council auditor *pro tem.* for the purpose.

The CHAIRMAN, in moving the adoption of the Council's Report, congratulated the Society on its continued prosperity and the usefulness of its work during the past session. The *Journal* had never been in so efficient a condition as at present, and owing to the Society's connection with the series of Exhibitions at South Kensington, it had been the means of communicating to the members, and the very large section of the public that looked at the *Journal* for instruction, some especially valuable matter.

Lord ALFRED CHURCHILL, in seconding the motion, remarked that the members must be fully satisfied with the work done by the Society in the past Session, and congratulated the meeting upon the satisfactory state of its finances.

Mr. T. H. BLAKESLEY, referring to the arrangements for the Conversazione, objected to the sale of tickets, and asked for the number of tickets issued before the system of sale was adopted, to compare with the present issue. With regard to the petition to the House of Lords against the Electric Lighting Bill, he expressed his regret that the petition had not been submitted to the members of the Society before its presentation, in order that its points might have been discussed by them.

Mr. ALFRED CARPMAEL explained that, on account of the shortness of time available for the preparation of the petition against the Electric Lighting Bill, owing to the hurried manner in which the matter was pushed through the House of Lords, it was necessary for the Council to draw it up, have it engrossed, and send it in, all within a space of twenty-four hours.

Mr. B. F. COBB (Treasurer) drew attention to the fact that the sale of tickets for the Conversazione, alluded to by Mr. Blakesley, brought no gain to the Society, as the whole of the amount was paid over to the Exhibition to meet the expenses. He referred to the approaching expiry of the lease of the Society's premises, and urged that, with this in view, it behoved the Society to strengthen its invested funds as much as possible.

Mr. WENTWORTH SCOTT, referring to the same subject, hoped that the Society might soon have increased accommodation, as the present meeting room was often found too small. He advocated the formation of a building fund.

The Secretary pointed out, in answer to Mr. Blakesley's question, that the numbers at the last four Conversazioni were as follows:—In 1882, at the South Kensington Museum, 2,790; in 1883, at the Fisheries, 6,500; in 1884, at the Health Exhibition, 14,080; and in 1885, at the Inventions Exhibition, 10,652. The expenses of the Conversazione in 1883 were paid by the late Sir William Siemens, then Chairman of Council; that in 1884 was a joint Conversazione of the Society and of the Executive of the Health Exhibition; and that in 1885 of the Society alone. Tickets were sold for the last two Conversazioni.

The ballot having remained open for one hour, and the scrutineers having reported, the Chairman declared that the following had been elected to fill the several offices. The names in *italics* are those of members who have not, during the past year, filled the office to which they have been elected.

President.

H.R.H. the Prince of Wales, K.G.

Vice-Presidents.

H.R.H. the Duke of Edinburgh, K.G.
H.R.H. Prince Albert Victor of Wales, K.G.
Sir Frederick Abel, C.B., D.C.L., F.R.S.
Duke of Abercorn, C.B.
Sir Edward Birkbeck, Bart., M.P.
Sir Frederick Bramwell, F.R.S.
Alfred Carpmael
Edwin Chadwick, C.B.
Lord Alfred S. Churchill.
T. Russell Crampton.
Prof. James Dewar, M.A., F.R.S.
Colonel J. F. D. Donnelly, R.E.
Captain Douglas Galton, C.B., D.C.L., F.R.S.
Sir Frederick Leighton, Bart., P.R.A.
Duke of Manchester, K.P.
George Matthey, F.R.S.
General Sir Henry F Ponsonby, K.C.B.
William Henry Preece, F.R.S.
Sir Robert Rawlinson, C.B.
Owen Roberts, M.A., F.S.A.
Lord Sudeley.
John Walter.

Ordinary Members of Council.

William Anderson.
William Henry Barlow, F.R.S.
Sir Francis Dillon Bell, K.C.M G.
Henry Doulton.
R. Brudenell Carter, F.R.C.S.
Charles Cheston, M.A.
Lieut.-Colonel A. C. Hamilton, R.E.
Sir Villiers Lister, K.C.M.G.
Robert James Mann, MD., F.R.C.S.
William George Pedder, C.S.I.
Sir Saul Samuel, K.C.M.G.
Sir Richard Webster, Q.C., M.P.

Treasurers.

B. Francis Cobb.
William Rolle Malcolm.

Secretary.

H. Trueman Wood, M.A.

The usual vote of thanks to the Scrutineers, moved by the Chairman, was carried unanimously.

Mr. Carpmael, in proposing a vote of thanks to the Chairman, alluded to the fact that his term of office as Chairman of the Society's Council ceased from that day, and remarked that the members owed him a deep debt of gratitude for the time and labour he had for so long devoted to the interests of the Society.

Sir Robert Rawlinson seconded the motion, which was carried unanimously.

Sir Frederick Abel, in replying, referred to the fact that he had had a somewhat longer term of office than was usual, owing to the lamented death of Sir William Siemens, his predecessor. Though the duties of Chairman of Council were no small tax upon his energies, it had been a pleasure to discharge them to the best of his endeavour. He concluded by proposing a vote of thanks to the Secretary and the other officers of the Society. This was seconded by Lord Alfred Churchill, and supported by Mr. Wentworth Scott, and was acknowledged by the Secretary.

Miscellaneous.

COLONIAL AND INDIAN EXHIBITION.

The number of visitors to the Exhibition for the week ending June 26th, was 171,899; making a total since the opening of 1,298,101.

STATUES OF COLONIAL WORTHIES.

By J. S. O'Halloran,
Secretary of the Royal Colonial Institute.

At a season when the Colonial and Indian Exhibition is making a profound impression on the people of these Isles, and awakening an abiding interest in the glorious heritage they possess in the Greater Britain beyond the seas, it seems peculiarly appropriate to consider for a brief space the work and worth of those hardy pioneers who have so well and truly laid the basis of a far-spreading empire on which the sun never sets. The pioneers of civilisation are called upon to encounter numerous difficulties and trials which can only be overcome by unwearying perseverance, enduring courage, untiring industry, and undimmed hope in eventual success. These high qualities are eminently characteristic of the Anglo-Saxon race, and have contributed to make them the most successful colonisers the world has ever known; and what nobler mission has been accomplished by our fellow countrymen than the founding of New Englands in every quarter of the globe, where the mother country lives again a more vigorous and, perhaps in days to come, a still grander life, in that ever-expanding Colonial empire which her sons have built up? The immediate aim of the writer is to place before the public the result of investigations which he was recently requested to undertake with a view to ascertaining to what extent the memory of our famous navigators, explorers, and other worthies, has been perpetuated in the mother country and in the Colonies, through the instrumentality of the sculptor's art. It is hoped that the meagreness of the present record may serve to call attention to some conspicuous omissions to do honour where honour is justly due, and tend to awaken a generous emulation throughout the empire to make it more thoroughly representative. It certainly excites the comments of many visitors to this metropolis that space has not been found for statues of such men as Columbus, Cabot, Cook, Flinders, Drake, and Raleigh, to each of whom this country owe so much. Nor are the Colonies entirely free from cause for reproach. In new countries there are, however, few men of leisure, and circumstances change with such rapidity that the work of those who have passed away, and upon the fruits of whose labours others have entered, is too apt to be forgotten.

CANADA.

The EARL OF SELKIRK founded the first settlement on the Red River in 1812, and his memory is justly held in high esteem throughout North Western Canada. In 1811 he purchased from the Hudson's Bay Company a large tract of fertile land along the courses of the Red and Assiniboine Rivers, and sent out as pioneers a party of Scotchmen, who were afterwards joined by some Norwegians and French Canadians. They were exposed to great privations and to the attacks of prowling Indians, but being for the most part hardy Highlanders, they persevered and eventually triumphed. The colony, which was first known as the Red River or Selkirk settlement, now forms part of the province of Manitoba. A bust, by Chantrey, is in the possession of the Countess of Selkirk, at St. Mary's Isle, Kirkcudbright.

JACQUES CARTIER, in 1534, was the pioneer of French exploration and settlement. In 1835 he occupied Quebec, and navigated the River St. Lawrence as far as Montreal. Bust by L. P. Hébert, of Montreal.

SAMUEL DE CHAMPLAIN, in 1602, visited Canada; in 1608 founded the city of Quebec; and in 1615 reached Lake Huron. Bust by L. P. Hébert, of Montreal.

MAISONNEUVE, the founder of Montreal. Bust by L. P. Hébert, of Montreal.

MONTCALM and WOLF.—Equestrian statues of these great and gallant men are being prepared by Mr. L. P. Hébert, of Montreal.

SIR GEORGE CARTIER, a prominent Canadian statesman, who died 20th May, 1873. In front of the Parliament buildings at Ottawa is a statue by L. P. Hébert, of Montreal.

SIR HECTOR LANGEVIN, Minister of Public Works of Canada. Statue by L. P. Hébert, in the Canadian Court of the Colonial and Indian Exhibition.

NEWFOUNDLAND.

JOHN AND SEBASTIAN CABOT first sighted Newfoundland in 1497. A movement is afoot for erecting a statue at St. John, which it is hoped will be accomplished at no distant date.

NEW SOUTH WALES.

CAPTAIN JAMES COOK, through his voyages of discovery between 1769 and 1777, first practically opened Australia, Tasmania, and New Zealand to European settlement. A bronze statue of the famous navigator stands in Hyde-park, Sydney, New South Wales. It is 13 ft. 6 in. in height, and is the work of Thomas Woolner, R.A., who still possesses the model. There is another statue at Randwick, by Walter McGill, of Sydney.

SIR RICHARD BOURKE, K.C.B., born 1778, was Governor of New South Wales from 1831 to 1837. A bronze statue, by Westmacott, stands in the Government Domain, as a record by the people of New South Wales "to his able, honest, and benevolent administration," and a tribute "of their gratitude for his services, their admiration of his public talents, and their esteem for his private worth."

THOMAS MORT, a colonist of New South Wales, whose investigations led to the successful importation of fresh meat into this country. Born in England in 1816, he arrived in Sydney in 1838, and identified himself with many movements for the advancement of the colony. He died in 1878, and a statue by Connolly, of Florence, was erected to his memory by public subscription.

Sir GEORGE GIPPS was Governor of New South Wales from 1837 to 1846, and died at Canterbury, in the cathedral of which city a marble monument has been erected to his memory.

WILLIAM CHARLES WENTWORTH, statesman and poet, was born at Norfolk Island, October, 1791, and died in England, March, 1869. He was one of the founders of the Sydney University, in the great hall of which is a statue in his honour, by Temerani. He foresaw with prophetic eye the future greatness of his native land,

> "And Australasia rise with flag unfurled
> A new Britannia in another world."

Sir GEORGE MACLEAY, K.C.M.G., was educated at Westminster, went to New South Wales in 1830, and accompanied Captain Sturt on his adventurous boat journey on the Murrumbidgee and Murray Rivers. He was for some years a member of the Legislature of New South Wales, and now resides in England. A marble bust, by Charles Summers, is in the possession of Sir George MacLeay.

VICTORIA.

ROBERT O'HARA BURKE and JOHN WILLS left Melbourne in 1860, with camels brought from India, and having succeeded in crossing the continent, died from starvation, at Cooper's Creek, on the return journey, in 1861. A colossal group, in bronze, by Charles Summers, forms a conspicuous object, which arrests the attention of visitors to Melbourne.

SIR REDMOND BARRY, K.C.M.G., born 1818, settled in Melbourne in 1839, and, after filling several important offices, was created a Judge of the Supreme Court in 1851. He may be regarded as the father of the Melbourne University, of which he was Chancellor from its foundation in February, 1855, to the time of his death in November, 1880. The people of Victoria are indebted to him for many of the works of art in the National Gallery, where a marble bust, by Thomas Woolner, R.A., has been placed as a memorial.

EDWARD WILSON, a leading journalist, gave much attention to the work of acclimatisation. He died in England, 9th January, 1878. There is a marble bust, by Thomas Woolner, R.A., in the Melbourne Public Library.

SOUTH AUSTRALIA.

CHARLES STURT, born April, 1795, was a captain in the 39th Foot; as ensign in which regiment he was the first to unfurl the British flag in the streets of Paris, after the battle of Waterloo. Starting from Sydney in 1828, he discovered the River Darling. In 1829 he followed the course of the Murrumbidgee to its junction with the Murray—the greatest of Australian rivers—which he descended 1,000 miles to its outflow into the sea at Encounter Bay, south of Lakes Alexandrina and Albert. Through great hardships and in constant peril from hostile natives, he—possessed of a rare combination of calm courage and great humanity—successfully accomplished the return journey with his party, safe, though exhausted; and, not only without once firing a shot at, but having established a friendship with, the aborigines. His discoveries led to the colonisation of South Australia. In 1844 he endeavoured to penetrate from Adelaide to the centre of Australia, which he reached within 150 miles, when, crippled by scurvy, his privations became unendurable, and he was compelled to return. He was nominated K.C.M.G. shortly before his death at Cheltenham, 16th June, 1869. A marble bust, by Charles Summers, the property of Mr. T. Halley Knight, of Holland-park, may be seen in the South Australian Court at the Colonial and Indian Exhibition. A replica has been placed in the Melbourne Public Library.

SIR WALTER WATSON HUGHES, a public-spirited and munificent colonist, who contributed liberally to expeditions for exploring the interior of the continent, and initiated the Adelaide University in 1872, by endowing two professorships. A marble bust, by Fugcini, has been placed in the hall of the University in honour of its respected founder, who now resides in England.

AUGUSTUS SHORT, D.D., born 1803, was the first Bishop of Adelaide, and ably presided over the vast diocese which he inaugurated, from 1847 to a short period before his death, which took place in England in 1883. A marble bust was provided by public subscription as a tribute to his memory. He was the first Chancellor of the Adelaide University.

TASMANIA.

SIR JOHN FRANKLIN, who afterwards became famous as an explorer in the Arctic Seas where he lost his life—was Governor of the colony from 1837 to 1843. A bronze statue was erected to his memory in Hobart in 1863. There is also a bronze statue, by Noble, in Waterloo-place, London.

NEW ZEALAND.

EDWARD GIBBON WAKEFIELD, as author of the "Art of Colonisation," deserves an honoured place in all records of Australasian development and progress, his system of dealing with the land by selling it at a substantial price and applying the proceeds to immigration having been largely adopted in Australia and New Zealand. He was born in London, March 20, 1796, and died at Wellington, New Zealand, May 16, 1862. A marble bust, with an appropriate inscription, may be seen at the Colonial-office in Downing-street.

JOHN ROBERT GODLEY, one of the Canterbury pilgrims, and the virtual founder of Christchurch, New Zealand, in whose memory a bronze statue by Thomas Woolner, R.A., has been erected in front of the cathedral.

WILLIAM SEFTON MOORHOUSE, born in Yorkshire in 1825, and emigrated to New Zealand in 1851. He twice filled the office of Superintendent of the Canterbury Province, viz., from 1857 to 1862, and from 1865 to 1868. His public services are well remembered; but the greatest and most enduring work which marked his administration was the construction of a tunnel, 2,800 yards in length, cut through the hard rock of a hill overlooking the harbour, and paving the way for railway communication between Port Lyttelton, the town of Christchurch, and the rest of the province. Mr. Moorhouse died in 1881, having been for many years a Member of the House of Representatives at Wellington. A bronze statue, by G. A. Lawson (provided by public subscription), has recently been placed in the gardens of the Domain at Christchurch, New Zealand.

(*To be continued.*)

BURMAN GOLD AND SILVER SMITHING.

The Burmese are adepts at artistic work in metal. Their gold work consists chiefly of female trinkets, the best being a kind of necklace called *bayet*, composed of several strings or chains of filigree work joined together, with little figures in red gold of the mythical *henza*, or sacred goose. The best silversmiths' work is seen in large bowls, embossed in high relief with fanciful designs. The plain cup or bowl, having been shaped, is filled with a resinous composition, in the centre of which is inserted a wooden pin, so that when the resin cools, the cup is fixed as on a lathe, the pin forming a handle. The workman then with a graver and hammer slightly marks out the pattern, which he delineates by sinking the surrounding metal into the yielding matrix.

A little *niello* work is executed on the same principles as the lacquered boxes. The pattern is made in silver slightly embossed, and the whole is coated with black varnish or enamel. The lathe is used to take the varnish off the raised ground, leaving the silver pattern in a black setting.

The smelting of silver for producing the currency of the country is carried on in the following manner. Silver, purchased from the Kakhyens (who procure it from the Chinese) to the amount of 6 *ticals* (say $3\frac{1}{6}$ oz.) is mixed with $1\frac{1}{2}$ *ticals* (378 grains) of copper wire, and the two metals are melted together, the smelter adding sufficient lead (judging the weight) to make up the total weight to 10 *ticals* ($5\frac{1}{2}$ oz.). The smelting is conducted in little saucers of sun-dried clay, placed on a bedding of paddy husk to make them lie evenly; charcoal is heaped up over them in hollow pyramids, which being ignited, the bellows are vigorously applied. As soon as the metals fuse, little pieces of lead are put in, according to the judgment of the smelter. When the mass is at a red heat, the charcoal is removed, and if a piece of wood, which is now held over the alloy, freely ignites, a round, flat, brick button, about the size of a five shilling piece, on which a smooth layer of moist clay has been spread, is laid on the surface of the molten mass, two men previously blowing upon it through bamboo tubes. The brick disc does not cover the whole of the alloy, and the surplus metal round the edge forms a thick ring, to which lead is freely added to bring the mass up to the proper size and weight. As it solidifies, there forms a white disc of silver surrounded by a thick, dark brownish ring, containing metal of the same purity as the disc, but covered with a coating of refuse and lead. The mass is removed from the saucer before it is perfectly hard, and the brick disc falls off, leaving the coating of moist clay adhering to the silver, which is then cleaned, and a number of round spots are dotted with cutch on the face of the alloy, to make the mass look pretty. It is then weighed and is ready for cutting up. The saucers in which the alloy is melted are sold at 80 rupees (£8) per 1,000 to the lead smelters, who extract any silver and lead that may remain; and the refuse of this smelting is sold to the potters, who use it as a glaze for tiles, while it appears to be sometimes also employed in *niello* work.

Correspondence.

SEWAGE BY WATER-CARRIAGE.

Mr. Martin Wood writes with reference to Dr. Tidy's remarks on water-carried sewage (see *ante*, p. 625):—

"I would direct Dr. Tidy's attention to the town and island of Bombay, the unfortunate population of which—the second in the British Empire—is in course of being now subjected to the dire experiment of water-carriage sewerage. It would be too long a story to tell how this artificial European abomination is being forced on that city in the tropics, at enormous cost, including, and with obvious and imminent peril to the health of its swarming 'chawls' and 'oarts.' If in this climate—sometimes styled temperate—Dr. Tidy regards the water-carriage system as adapted to 'steal our health,' and annoy with its 'perpetual nuisance,' by what formula of scientific progression will he estimate the pestilent effects of that system in the (mainly) low-lying island of Bombay, where the mean temperature averages eighty degrees? It is true he can have no feeling of responsibility as regards either Bombay or Calcutta (and similar remarks apply to the latter city), but as he confesses to having thought very earnestly on the subject, it cannot be amiss for me thus to assure him that there is yet a chance for that earnest thought being directed towards checking the extension of the evil system under conditions where its noxiousness will be at least tenfold. Possibly one or other of the recently half-poisoned senators at St. Stephen's may be induced to take up Dr. Tidy's parable, and ask if it is too late to save Bombay and rescue Calcutta from the artificial production of zymotic disease?"

MEETINGS FOR THE ENSUING WEEK.

The following are Conferences for the week ending July 10th, at the Colonial and Indian Exhibition:—

MONDAY, JULY 5...Conference of the Anthropological Institute. "Races (Aboriginal) of India." 4 p.m. Mr. R. L. Nash, "Trade and Commerce of Queensland." 8 p.m.

TUESDAY, JULY 6...*Congress of the Chambers of Commerce of the Empire. 10 a.m.

WEDNESDAY, JULY 7...*Congress of the Chambers of Commerce of the Empire. 10 a.m.

THURSDAY, JULY 8...*Autumnal Meeting of the Chambers of Commerce of the United Kingdom who are Members of the Association of Chambers of Commerce. 10 a.m.

FRIDAY, JULY 9...Mr. J. Sivewright, "Colonial Telegraphs." 4 p.m.

SATURDAY, JULY 10...Dr. Brandis, "The Forests of India." 4 p.m.

* At these Conferences the admission will be confined to Delegates of Chambers of Commerce.

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FRIDAY, JULY 9, 1886.

All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

NOTICES.

CONVERSAZIONE.

The Society of Arts Conversazione will be held, by permission of the Royal Commission, at the Colonial and Indian Exhibition, South Kensington, on Friday next, the 16th of July.

The Reception will be held in the Middle Court (Indian Empire) by Sir Frederick Abel (Chairman of the Council), and the other members of the Council.

Each member has received a card for himself, which is not transferable, and a card for a lady. In addition to this, tickets can be sold to members of the Society, or to persons introduced by a member.

Members can purchase these additional tickets by personal application, or by letter addressed to the Secretary. In all cases of application by letter, a remittance must be enclosed. Each ticket will admit one person, either lady or gentleman.

Tickets will only be supplied to non-members on their presenting members' vouchers (forms of which can be obtained from the Secretary), or a letter of introduction from a member.

The issue of tickets will be strictly confined to members of the Society and their friends, and to those specially invited by the Council.

The price of tickets is now 10s. each. On the 16th July, the day of the Conversazione, the price will be 15s. Each ticket admits one person only.

The bands of the Grenadier Guards, of the Royal Horse Guards, and of the First West India Regiment, will perform during the evening. Concerts will be given by the glee-singers from the Criterion, and by Mr. Harry Tipper's Company of bell-ringers and glee singers.

There will be special displays of the illuminated fountains.

A District Railway special train will leave South Kensington at 12.33 (*viâ* Charing-cross and Mansion-house), calling at all stations to Whitechapel.

A Metropolitan Railway special train will leave South Kensington (*viâ* Praed-street and Edgware-road), calling at all stations to Aldgate.

The subway will be available for the use of visitors, and will remain open till the departure of the special trains. Visitors to the Conversazione can obtain their tickets at the booking-office in the subway.

Light refreshments (tea, coffee, ices, fruit, claret-cup, &c.) will be supplied at the usual buffets. No refreshments can be obtained by purchase.

There will be no admission to the Exhibition on this evening except by special ticket, and no tickets can be purchased at the Exhibition.

Proceedings of the Society.

CANTOR LECTURES.

PETROLEUM AND ITS PRODUCTS.

By Boverton Redwood, F.I.C., F.C.S.

[The right of reproducing these lectures is reserved.]

Lecture III.—Delivered March 22, 1886.

The third division of our subject relates to the processes adopted for the manufacture and distribution of the various commercial products, as well as to the methods employed for ascertaining the quality of these products, and their suitability for the purposes to which they are to be applied.

Petroleum, as we have seen, consists of a mixture of hydrocarbons of varying volatility, and the first operation performed upon the crude oil consists in the partial separation of these hydrocarbons by a process of fractional distillation. Before proceeding to describe the apparatus and process, however, I should mention that some of the heavier crude oils are used for lubricating purposes, either in the state in which they are obtained from the wells, or after their density has been increased by the evaporation, at a comparatively low temperature, of a portion of the more easily volatilised hydrocarbons present. Such oils, called "natural oils," or "reduced oils," are found to be of greater lubricating value than distilled oils of similar density. They are often purified by filtration through animal charcoal.

In the manufacture by this process of the best oils for the lubrication of steam-engine cylinders, a product of less density is obtained, which, after being filtered through animal charcoal, and subsequently deprived of fluorescence (or "debloomed," as it is technically termed) by exposure to the sun, is known as "neutral oil." The product is employed for oiling wool, and sometimes as a spindle oil in silk mills, where a specially fine oil is required. The term "amber oil" is commonly applied to an oil made similarly to cylinder oil, but of less density. This oil, which is red rather than amber in colour, is purified simply by filtration through animal charcoal, and therefore without the use of acid. It is to some extent used as an engine oil in the United States, and as a lubricant for printing presses. Specimens of these oils are on the table.

The first attempts to refine petroleum commercially in the United States were probably made in the year 1854, when a still, having a capacity of five barrels, was erected in Pittsburg, for refining the small quantity of crude oil obtained in the neighbourhood; but the scarcity of the raw material prevented for some time any important development of the industry. Up to the year 1862, the stills commonly employed had a cylindrical cast-iron body, with boiler-plate bottom and cast-iron dome with goose neck bolted on. The capacity of these stills was usually about twenty-five barrels, and the charge was distilled to dryness. At the present time the process of distillation is divided into two distinct parts. In the first part of the process, stills of two forms are usually employed. These forms are respectively the plain cylindrical still, and what is known as the "cheese-box" still. The former consists of a cylinder of boiler plate,* 30ft. in length by 12ft. 6in. in diameter, furnished with a dome 3 ft. in diameter, from which passes a vapour pipe 15 in. in diameter. This still is set horizontally in a furnace of brickwork, usually so constructed that the upper part of the still is exposed to the air. The "cheese box" still has a body and dome-shaped top of boiler-plate, and a double curved bottom of steel plate. It is 30ft. in diameter and 9ft. in height, and is set on a series of brick arches. The vapour is passed from the still through three pipes into a vapour chest, and thence through forty 3-inch pipes. The form of the stills is shown by the models on the table. Wet steam is usually introduced into the exit pipes of these stills, so that it may mingle with the vapour. The working charge of the cylindrical stills is about 600 barrels, and of the cheese box stills about double that quantity. Connected with the stills are the condensers. These were formerly copper worms, but now consist of iron pipes, usually straight, passing through tanks of cold water. A modern condensing arrangement may be described as consisting of a series of forty separate 3-inch pipes, the vapour passing in at one end, and the condensed oil flowing out at the other end of each pipe. In some cases, methods of fractional condensation, more or less complicated, designed to effect the more complete separation of the commercial products, are adopted.

In the second part of the process of distillation, cylindrical stills, which are commonly of steel, and hold about 260 barrels, are employed.

The crude petroleum, on reaching the works, is placed in storage tanks, and is thence pumped into the stills. A fire having been lighted in the furnace beneath the still, the temperature of the oil is gradually raised, and the more volatile constituents distilled off. The crude naphtha thus obtained is sometimes collected in two fractions. Sufficient of the lighter hydrocarbons having been separated to give the next commercial product (which is the burning oil of commerce) the required flashing point or fire test, the distillation is continued until a point is reached at which the operation must be arrested, otherwise the burning oil would have too high a specific gravity. The product of burning oil is frequently divided into two or more fractions. In practice, the termination of the collection of the naphtha and of the burning oil respectively takes place when the distillate issuing from the condensers reaches a specified density. The per-centage of these two commercial products varies according to the character of the crude oil, and the method of distillation; the average yield may, however, be stated to be about 12 per cent. of naphtha, and 75 per cent. of burning oil (110° fire test). Of the higher class of burning oil, known as "water white oil," only from 12 to 20 per cent. is obtained. The fluid residue in the still, known as residuum, and amounting to about 6 per cent., having been run off, there remains a quantity of coke, which represents 1 per cent. to 1½ per cent. of the original charge. The time occupied in working a charge is from three to four days. This separation of the naphtha and burning oil constitutes the first part of the process of distilling the crude petroleum. The second part of the process, which is usually conducted at other works, consists in distilling the residuum to dryness, and obtaining lubricating oils and solid paraffin. The residuum, which has an average specific gravity of about 19° B. (equal to ·942), is, when practicable, conveyed from one refinery to the other in bulk barges. The time occupied in the working of the charge is about thirty hours. The distilled products are collected in several fluid fractions, holding the solid hydrocarbons in solution. The coke which remains in the still at the end of the process amounts to about 12 per cent. Superheated steam is often passed into the stills during the distillation. In the production of some of the special grades of "reduced oils," vacuum stills are employed. The crude naphtha is redistilled by steam heat in cylindrical stills holding 500 barrels, and is sometimes separated into the following commercial products, the more volatile of which are colourless :—

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* The lower half of the cylinder is generally of steel.

No.	Density.	Name.	Use.
1.	90°B	Rhigolene or cymogene.	For surgical purposes.
2.	88°/86°,,	Gasoline.	,, Air-gas machines.
3.	76°,,	Boulevard gas fluid.	,, Street naphtha lamps.
4.	73°/68°,,	Prime city naphtha (benzoline)	,, "Sponge lamps," &c.
5.	62°,,	Benzine.	,, Oil-cloth and varnish making.

The time occupied in working the charge is about 48 hours. The percentage of these products varies, but as a rule amounts to about 25 per cent. of the first three collectively, rather more than 25 per cent. of the 4th, and about 40 per cent. of the 5th.

Such is an outline of the method of distilling crude petroleum in the United States. There are, however, many detail variations, the precise conditions under which the operation is conducted being by no means uniform. In all cases, however, the principal object in view is to obtain the largest yield of burning oil, lubricating oil and paraffin, consistent with these products being of satisfactory quality.

The next step in the process of refining consists in a treatment of the distillate with sulphuric acid. This operation is conducted in tall cylindrical wrought iron tanks, 40 feet or more in height by 20 feet or more in diameter, sometimes lead-lined, holding from 1,200 to 1,800 barrels, and termed agitators. The oil having been pumped into the tank, a blast of air under a pressure of 5 to 7 lbs. per square inch is introduced through a pipe at the base of the tank, and the oil thus brought into a condition of active agitation. Oil of vitriol is then forced to the top of the tank by air pressure, and is gradually "showered" into the petroleum through a perforated leaden pipe, in the proportion of about 6 lbs. of acid to one barrel of oil. After the agitation has been continued for a sufficient length of time to bring the acid thoroughly into contact with the oil, the air blast is shut off, and the tarry acid (termed acid tar or sludge acid) having been allowed to settle to the bottom of the tank, is drawn off. The acid is occasionally recovered and concentrated for further use. The oil is then agitated with water, next with a solution of caustic soda, to complete the removal of the acid, and finally with water again, to which sometimes a little ammonia is added. The oil is then run into a shallow rectangular iron tank, usually provided with a steam coil for raising the temperature in cold weather, where the water which it contains settles out, and the oil becomes bright. In connection with this tank there is an arrangement for "spraying" the oil. This operation consists in running the oil in fine streams through small orifices in pipes placed above the tank, and its effect is to remove some of the more volatile hydrocarbons present, and thus bring the "test" of the oil up to the required point. From the settling tanks the oil passes to the barrelling or canning tanks.

The treatment of the less volatile of the naphtha distillates with acid is similar to that which is applied to the oil, but mechanical agitation, by means of a vertical revolving shaft fitted with arms, is usually substituted for the air blast, as the latter would cause the evaporation of the more volatile constituents. A similar method of agitation was formerly adopted in treating the burning oil. The acid treatment is applied to the naphtha with the object of deodorising, but in the case of the oil an improvement of colour as well as of odour results.

The lubricating oil distillates are also treated with acid, but before being subjected to this process they are cooled in order to separate the solid hydrocarbons. The cooling was formerly effected somewhat rapidly, but it has now become the practice to operate upon a considerable bulk of oil, and to reduce the temperature slowly, as it is found that the paraffin is thus obtained in a more crystalline form. The cooling or chilling tanks, employed at some of the most modern works, have a capacity of 3,000 gallons, and the period occupied in the cooling is as much as twenty-six hours. The reduction of temperature is effected through the medium of a solution of magnesium chloride, brought to the required temperature by means of an ammonia refrigerating apparatus. This liquid circulates through a number of cells alternating with similar cells containing the oil. At the expiration of the period named, the semi-solid mass is removed from the cooling tank, placed in bags, and subjected to hydraulic pressure at a temperature of 40° F. To effect a further separation of the oil, the press cakes are then broken up, or melted and recrystallised, and subjected to a second pressure of about 200 lbs. per square inch at a temperature of 70°. The residuum yields about 9 per cent. of paraffin by this treatment. For the production of hard and colourless paraffin wax, or of wax suitable for candle making, the paraffin scale obtained as described is purified by crystallisation from petroleum spirit, or by exposing it to a temperature just sufficient to cause the fusion and draining out of the hydrocarbons of lowest melting point, and by subsequent filtration through animal charcoal. This operation is largely conducted in this country by Price's Patent Candle Company and others. The expressed oil, which varies in specific gravity, according to the manner in which the various fractions have been separated in the process of distillation, is then subjected to an acid treatment, similar to that which the burning oil undergoes, and is thus converted into finished lubricating oil.

Some lubricating oils are finished by evaporation and by filtration through animal charcoal, the best oils for the lubrication of engine cylinders passing through the latter process. Petroleum lubricating oils consist chiefly of olefines ($C_n H_{2n}$). The most volatile of the fractions obtained in the distillation of the petroleum residuum, having a specific gravity of ·820 (42°B.) and low flashing point, contains but little paraffin, and is sold for gas-making in the condition in which it issues from the condensers.

The semi-solid mixture of uncrystalline hydrocarbons, known as vaseline, is obtained by the Chesebrough Manufacturing Company, under their patent, by evaporating off the more volatile portion of a suitable kind of crude petroleum and purifying the residue by filtration through animal charcoal. The product thus obtained is a colourless or pale yellow translucent semi-solid, possessing slight fluorescence. It is freely soluble in petroleum or shale spirit, benzol, ether, chloroform, carbon disulphide and turpentine. Vaseline is a mixture of hydrocarbons of which the chemical composition chiefly ranges from $C_{16} H_{34}$ to $C_{20} H_{42}$. There is reason to believe that olefines are present, but the substance consists mainly of paraffins.

The yield of burning oil from a crude petroleum of given quality has been largely increased during recent years. This has been accomplished by the adoption of the process known as "cracking." We have seen that the crude petroleum produced in the States of Pennsylvania and New York consists principally of the hydrocarbons known to chemists as paraffins. The researches of Thorpe and Young have demonstrated that the paraffins ($C_n H_{2n+2}$) when heated to temperatures above their boiling points, are converted into olefines ($C_n H_{2n}$), carbon being deposited, and gaseous products evolved. It is this operation of dissociation which is termed "cracking," and its employment enables the refiner to break up the hydrocarbons which are too heavy to be burned in ordinary lamps, and too fluid for use as lubricants, and convert them into hydrocarbons which may be allowed to pass into the burning oil distillate without unduly increasing its density. The process of cracking is carried out by conducting the operation of distilling the burning oil so slowly that the less volatile hydrocarbons become condensed in the upper part of the still, and fall back into the heated oil, where they are heated to temperatures above their boiling points, and become "cracked." A far larger yield of burning oil is thus obtained. The gaseous products are conducted into the still furnace, and serve as fuel. This process has been subjected to a good deal of adverse criticism, based upon the view that the chemical composition of the olefines renders them inferior to the paraffin for illuminating purposes, and that their capacity of forming substitution compounds with the acid used in refining leads to the contamination of the burning oil with sulphur products. There is no doubt good theoretical ground for this contention, and I have myself frequently found that the American petroleum oil of commerce, though showing no trace of the presence of acid when shaken with barium chloride solution, is blackened on heating, and during distillation gives off sulphur dioxide. I am not, however, prepared to say that in the practical use of the oil any distinct disadvantage can clearly be traced to the action of the operation of cracking, and it is obviously to the interest of the poorer classes, who so largely use petroleum oil as a source of light and heat, that a system of manufacture which considerably increases the yield, and therefore diminishes the cost of the product, should not be hastily condemned. Moreover, it should be borne in mind that the proportion of cracked oil in the product is not usually very large, and, therefore, that objections which would attach to the use of the cracked oil alone may not apply to the product as a whole. By some it is claimed that distillation of the burning oil over caustic alkali has the effect of removing the substitution products formed in the acid treatment. The burning oils chiefly manufactured in the United States are of the following grades:—110° fire test, 70° Abel test; 120° fire test, 73° Abel test; 150° fire test.

The colour of the first four grades usually ranges from "Prime White" to "Standard White" (straw colour to pale yellow), while the fifth grade is "Water White" (colourless). The rules of the New York Produce Exchange provide that refined petroleum for contract purposes shall be standard white or better, with a burning test of 110° Fahrenheit, or upwards, and a specific gravity not below 44° Beaumé, United States Dispensatory Standard (not above ·811 specific gravity). Formerly the bulk of the oil intended for export was refined to 110° fire test, the United Kingdom, however, taking 120° fire test oil. Since the introduction of the Abel system of testing, however, a large proportion of the oil has been refined to a test of 70° Abel for shipment to the Continent of Europe, and of 73° Abel for shipment to this country. The oil of 150° fire test is considerably lower in specific gravity than the other grades (say ·786 to ·793). Oils are also specially refined, that is, made to stand special tests, for use in the various States of the Union, as we shall presently see when considering the subject of testing. In addition to the products enumerated, an oil of high specific gravity, and high flashing point, intermediate in character, in fact, between the ordinary burning oils and the lubricating oils, is made. This oil was originally produced by the Downer Kerosene Oil Company, under the name of mineral sperm oil, for use in lighthouses, and its use is now compulsory on some of the American railroads. It is also largely used on board ship. Of this oil, as now manufactured, the crude petroleum yields about 10 per cent., the product having a specific gravity of about ·829, and a fire test of about 300° F. (Flashing point, open vessel, about 270° F.; closed vessel, about 240° F.). This product is frequently termed mineral colza oil, or mineral seal oil.

Through the courtesy of several of the American refiners, I am able to place before you samples of the various products in different stages of manufacture.

The number of grades of lubricating oil manufactured are so great, and their qualities so various, that it is difficult to give any satisfactory enumeration of them. The oil varies in colour from yellow to very dark red, and is strongly fluorescent. I have on the table a large selection of the lubricating oils sold by the Thompson and Bedford Company, Limited, including the following:—

Pale oils—sp. gr. 885, 905, 915, 920.

Amber machinery oil.

Dark machinery oils—Summer, winter, medium.

Cylinder oils.

This company also sells an oil for wool dressing, a curriers' oil, as well as rope and jute oils. "Bloomless" oils, devoid of the natural fluorescence of petroleum products, are also made.

The solid paraffin (using the term in its commercial sense) is, like the oil, a mixture of various hydrocarbons of different specific gravities, boiling points, and melting points. The paraffin scale separated from the oil of ·905 specific gravity has an average melting point of about 125° F. (American test), and that from the oil of ·885 specific gravity a melting point of about 117° F.

"Paraffin wax," manufactured as already described, is a white or bluish-white translucent waxy solid of lamino-crystalline structure, devoid of taste and smell. The hydrocarbons of which it is composed are characterised by chemical indifference; hence the name (*parum affinis)*. The specific gravity, melting point, and boiling point of the material vary with its composition. At a temperature below its melting point paraffin wax becomes plastic, a characteristic which is of such practical inconvenience when the substance is used as candles, that it is the practice in candle making to add a small quantity of stearic acid, which to some extent diminishes the tendency of the candle to bend in a warm room.

When two pieces of paraffin wax are struck together, a sharp metallic sound is emitted, especially if the melting point of the specimen be high. Exposed for some time under a slight pressure to a temperature below its melting point, paraffin wax undergoes a molecular change, and becomes transparent; but upon a change of temperature, or upon being struck, the original translucent appearance returns.

Paraffin wax is freely soluble in petroleum or shale oil and spirit, in ether, in benzol, and in essential oils, It is sparingly soluble in hot absolute alcohol, but separates on cooling. It is insoluble in rectified spirit and in water.

When boiled with concentrated nitric acid, paraffin is oxidised with the formation of succinic acid, and a small quantity of butyric acid. Paraffin is also oxidised when heated with potassium permanganate and sulphuric acid. At a high temperature it is slowly attacked by concentrated sulphuric acid, and chlorine passed into melted paraffin attacks it slowly. When heated with sulphur, paraffin is decomposed, sulphuretted hydrogen being evolved and carbon deposited.

A considerable quantity of crude petroleum is exported from the United States to France, to be refined there, the French duty on the refined oil encouraging the home industry. The rules of the New York Produce Exchange provide that crude petroleum shall be understood to be pure natural oil, neither steamed nor treated, free from water, sediment or any adulteration, and of the gravity of 43° to 48° Beaumé (·816 to ·794 sp. gr.).

Crude naphtha and residuum are also exported in comparatively small quantities. The naphtha is required to be water white and sweet, and of gravity from 68° to 73° Beaumé, while the residuum is to be understood to be the refuse from the distillation of crude petroleum, free from coke and water, and from any foreign impurities, and of gravity from 16° to 21° Beaumé (·96 to ·93 sp. gr.).

Natural and reduced lubricating oils (West Virginia, &c.) are sold under contract rules, fixing the limit of setting point, the latter oils being divided into two grades termed respectively summer reduced oil and winter reduced oil.

Some of the refineries in the United States are of great size. Thus the works at Bayonne, New Jersey, owned by the Standard Oil Company, in whose hands the greater part of the refining trade is concentrated, covers about 67 acres, and is capable of turning out from 10,000 to 12,000 barrels of refined oil per day. At some of the most modern works, the plant is for the most part uncovered by roofing. Precautions are, however, taken against the spread of fire, water sprinklers and steam jets being fitted to the storage tanks, and hydrants being provided. At all large refineries there is a well-drilled fire-staff. At the Bayonne works the fire brigade is drilled twice a month, and on the occasion of my visit, four fire hoses were brought into action upon a tank in 30 seconds, 1 min. 10 secs., 1 min. 20 secs., and 1 min. 30 secs. respectively from the blowing of the alarm whistle, three of the hoses being brought some distance. At the works of the Pratt Manufacturing Company there is a fire wall which prevented the spread of fire from a burning tank some time ago, although, according to evidence laid before me, the fire burned with great fierceness until the whole of the oil in the tank had been consumed, and the wind was blowing towards the wall. It is considered that a properly protective fire wall should be 5 feet higher than the tank, and about 10 feet distant from it.

A considerable proportion of burning oil for consumption in the United States is now transported over the railways in tanks, even water white oil being thus conveyed to Chicago, or sometimes as far as San Francisco, and is distributed in tank road waggons, which deliver the oil at the shops of the retailers, or even at the doors of the consumers. Barrels holding about fifty American gallons and tin cans of various sizes are also employed. At the present time, Mr. Edward Phillips is engaged, in conjunction with Messrs. Fraser and Sons, in the construction of appliances for the delivery of petroleum oil in bulk from the wharves in London to the storage tanks of the retailers.

The export of the oil has, with the exception of one shipment to be referred to, hitherto taken place exclusively in barrels of the size mentioned, or in tin cans of rectangular form, holding five American (or four Imperial) gallons, which are packed in twos in wooden cases. The manufacture of the barrels, cans, and cases, is, as may be supposed, a very important business. The barrel works of the Standard Oil Company at Bayonne are capable of turning out 10,000 to 12.000 barrels per day, and the operation of barrel making at these works is an interesting one to witness. The oak staves are purchased, ready jointed and seasoned, in Michigan, and the barrel heads are brought to the Bayonne works ready glued up. At the time of my visit there were more than a million heads in stock. The first operation in barrel making at these works consists in fitting the necessary number of staves together in a thick wrought-iron ring encircling their lower ends. This is an operation requiring some experience and judgment. The embryo barrel is then placed in an iron cylinder and steamed, whereby the wood is softened. The staves are next encircled by a wire rope connected with an engine, and are thus bent into shape and drawn together, a second strong iron hoop being slipped over their upper ends, to hold them in position. The barrel is then "fired" by burning some readily-combustible material in the interior, and the curvature of the staves thus rendered permanent. A number of extra temporary iron hoops of great thickness are next slipped on, and drawn towards the bulge of the barrel by means of an ingenious arrangement of iron hooks or claws, actuated by steam-power. The final operation performed upon the staves consists in placing the barrel in a lathe, paring off the rough ends, and cutting the grooves for the heads. The barrel is then ready to receive the heads, and to be hooped. The hoops weigh collectively about 12 lbs., and the total length of iron required for a set is 443½ inches, so that, putting the out-turn of finished barrels from this one factory at 10,000 per day, we have a length of about 70 miles of hoop iron (weighing about 55½ tons) used daily.

In order to render the barrels capable of holding their fluid contents without leakage, they are coated internally with glue, about 1 lb. of glue to 3 barrels being required. The glue solution is poured into the barrels hot, the barrel bunged up, and rotated so that the solution coats the entire surface, the surplus being afterwards drained out. There is some pressure of steam in the barrel during this operation, and a leak is thus at once shown. The barrels finally receive a coating of the well-known blue paint on the staves, and white paint on the heads. Old barrels returned to be refilled are often cleaned externally by an arrangement of rapidly revolving wire brushes, are steamed out, reglued, and repainted.

Before the barrels are filled, the hoops require "driving," to take up the shrinkage of the wood. This was formerly done exclusively by hand, but Mr. Hopper has invented a successful machine for doing this by steam power. In this apparatus the barrel stands on a platform arranged like an inverted steam hammer, and on turning on the steam is brought with a succession of blows against a number of hinged stops, which closely encircle the barrel and on which the hoops strike. With one such machine the hoops of 2,000 barrels can be driven in ten hours by one man and two boys, an amount of work which formerly entailed the hand labour of ten men.

The barrels are filled from a rack provided with a series of pipes connected with a barrelling tank. Each pipe has at its exit end a float connected with a valve, which shuts off the oil when the barrel has been filled to within one gallon of its contents. The shives with which the barrels are closed are of wood, and are put in with glue. A package which remains perfectly tight and free from leakage as long as it is handled carefully, and the continuous skin of glue remains intact, is thus produced.

The manufacture of cases is perhaps an even more interesting sight. At the Devoe Works, where I witnessed it, no less than 60,000 cans and 30,000 cases can be turned out per day. The first operation in the making of the cans consists in trimming the edges of the tin plates with a cutting machine capable of trimming 250 boxes of 120 sheets each per day. The trimmed plates then pass to the next machine, which cuts the ends off, stamps the panels, and bends the edges for the laps. Another machine bends the plates at a right angle, and another forms the body of the can by clinching the two sheets together. Yet another machine cuts out the tops and bottoms, and stamps the panels on them, another puts the top and bottom into the body at the rate of 3,500 cans per day, and another rolls the joints to make them secure, at the rate of 10,000 cans per day, with the labour of one man and two boys. The aciding and soldering of the joints is also accomplished by highly ingenious machinery, the solder being kept fluid by air-gas flames. The galvanised wire handles are cut and bent by machinery, and the tin attachment similarly made, the only operation performed by hand in the case of those tins which have exclusively angle joints being the soldering on of the handles. In the construction of the caps with which the cans are closed, machinery is also employed, the caps passing through nine different operations. The caps are in two parts, the outer being removable by unscrewing; the inner cap can therefore be perforated when the oil is required for use, and the outer cap replaced to preserve the contents of the can from evaporation.

The wood used in the construction of the cases is Canadian pine, and the cases are very rapidly nailed by machinery; one nailing machine which I saw in action taking the nails from a hopper, and neatly inserting them at the rate of 5,500 to 6,000 complete cases per day. I was told that the maximum capacity of this machine, under skilful handling, was no less than 6,700 cases per day.

I have on the table a set of patterns illustrative of the process of can manufacture. The cans are filled on a revolving table provided with an automatic arrangement for shutting off the oil when a given weight has been delivered into each can. The caps are then soldered on, and the cans placed in pairs in the cases.

The can of petroleum is a package standing a good deal of rough usage. Thus, I saw a filled can taken from stock, and thrown to a considerable distance in the air. It fell on one corner on the wooden floor of the warehouse, and was knocked somewhat out of shape, but on picking it up I found that it was quite free from leakage. The empty can is so strong, notwithstanding that the tin plate of which it is made is thin, that a full-sized man may stand upon it without crushing it. Cans are used exclusively in the shipment of oil to warm climates, as the barrel, though less expensive per gallon of oil, is liable to become leaky when subjected to a high temperature.

Within the past few months two vessels, the *Crusader* and the *Andromeda*, have been fitted with tanks for the conveyance of the refined burning oil in bulk. The former vessel is provided with an arrangement of tanks patented by Mr. L. V. Sone, of New York. The patent specification contains twelve claims, but the most important feature of the system appears to be the provision of auxiliary tanks above the level of the storage tanks and in communication with them. The storage tanks can thus always be kept quite full of oil, the auxiliary tanks serving to hold the surplus when the contents of the storage tanks become expanded by heat, and supplying the deficiency when contraction takes place. The tanks with which the *Crusader* is fitted are of boiler plate, cylindrical in form, of various sizes, but of the average capacity of 125 barrels. There are 45 tanks, and the total carrying capacity of the vessel is, therefore, about 5,500 barrels. All the tanks are connected with a steam pump on deck, by means of which they can be charged or discharged in about ten hours.

About a month after the *Crusader* arrived in London, the *Andromeda* reached Bremen with a cargo of 684,641 American gallons of petroleum oil in bulk. This vessel contains 72 tanks, which instead of being cylindrical are principally rectangular. Expansion tanks similar to the auxiliary tanks of the *Crusader* are provided.

The only special feature in the process of refining petroleum in Canada is the treatment of the burning oil distillate with a solution of litharge and caustic soda for the purpose of removing sulphur. Notwithstanding the adoption of this process, the refined petroleum, or burning oil, has not, however, always been free from this impurity. In 1876, a sample of Canadian petroleum oil was submitted to me which produced a deposit of a bluish-black colour on the chimney of the lamp in which it was burned. On examining the deposit I could distinctly see small beads of liquid, which were deposited where the glass was very hot, and a piece of litmus paper applied to these beads was reddened and then charred. On washing out the chimney with water, and adding to the liquid a solution of barium chloride, a copious precipitate was produced. It was evident that the liquid condensed on the glass was sulphuric acid, and on burning a weighed quantity of the oil, and collecting the products of combustion, I found that sulphur was present in the oil to the extent of 116 grains per gallon. Another sample of Canadian oil, brought to me subsequently by a gentleman who had burned the oil in a greenhouse, and had found the plants injured in a manner that to him was inexplicable, contained 119 grains of sulphur to the gallon.

We now pass to the consideration of the method of refining and transporting petroleum oil adopted in Russia. Most of the Caucasian refineries are situated in the Tchornī Gorod or Black Town of Baku, on the shores of the Caspian. There may be seen refineries of all sizes, the smallest being constructed and managed in a primitive fashion. The largest works are those of the Nobel Company, an organisation occupying in relation to the refining of Russian petroleum, a position analogous to that which the Standard Oil Company holds in regard to the American refining trade. The works of the Nobel Company cover from 78 to 80 acres, and the dwellings of the *employés* another 40 acres. In regard to the substantial character of the buildings, and completeness of the arrangements, the refinery is equal to any that I have seen in the United States. The only essential respect in which the plant differs from that which I have already described, in treating of the American refineries, is in the adoption of a process of continuous distillation, the stills, each of the capacity of 4,400 gallons, being arranged in groups or series of not more than twenty-five, and a stream of oil continuously flowing through the entire number. The crude oil entering the first still parts with its most volatile constituents, passing into the next still, has rather less volatile hydrocarbons distilled from it, and finally flows from the last still in the condition of residuum, which, in Russia, is termed *astatki* or *masut*. The several stills are maintained at temperatures corresponding with the boiling points of the products to be volatilised. Attempts have been made to carry on a system of continuous distillation of petroleum in America, and an apparatus for the purpose was patented in the United States by Stombs and Brace, of Newport, Kentucky, April 10, 1860 (Patent No. 27,842), but the process has never been practically employed in that country. Mr. Ludwig Nobel informed me that the method of continuous distillation adopted in his works was specially suited to Baku petroleum, the quantity of burning oil separated being comparatively small, and the residuum, therefore, not very much less fluid than the crude oil. The fuel used under all the stills in Baku is petroleum residuum or *astatki*. At many of the smaller works, the liquid fuel is simply allowed to flow on the hearth of the furnace, and in thus using it a very large amount of dense black smoke is evolved; but in the larger and better conducted refineries, arrangements are adopted for burning the fuel with a proper admixture of air, and smokeless combustion is thus obtained. At the Nobel refinery the two most volatile distilled products are of specific gravity ·754, and ·787 respectively, while the kerosene (burning oil) has a specific gravity of ·820 to ·822. The more volatile products are largely burned as fuel, as there is little demand for them, and in fact a considerable quantity is burned to waste in order to get rid of it.

At the Nobel works the kerosene distillate is pumped into lead-lined agitators of the capacity of 57,000 gallons, where, in the manner already described, it is treated with about 1½ per cent. of sulphuric acid, washed with sea water (fresh water being very scarce in Baku), treated with caustic soda solution, and washed again. The oil then passes to the settling tanks, and is afterwards stored in large tanks, one of which holds 1,500,000 gallons. The whole process of treatment occupies 15 to 16 hours. The sulphuric acid is made in a neighbouring factory, from sulphur imported from Daghestan. The oil is almost superfine white in colour, and has an average flashing point of about 32° C. (Abel test). Of such product the crude oil yields, on an average, only about 27 per cent., and of oil quite free from colour, or water white, and having a flashing point of 50° C., only about 22 per cent. can be obtained. At the time of my visit to Baku, the Caspian Company were making three grades of burning oil of the respective specific gravities and flashing points of (1)·815—30° C., (2) ·820—25° C.,(3) ·821/·822—22° C. Of the first quality, the crude oil yielded 20 per cent., of the second 33 per cent., and of the third 38 per cent. The yield of burning oil from Baku petroleum is therefore comparatively very small, and to this the fact that the oil, although of so high a specific gravity, burns well is no doubt partly due, since the product is necessarily very homogeneous, the most volatile hydrocarbons present not differing very greatly in boiling point from the least volatile present. Besides this, however, the hydrocarbons of which the Baku oil is composed possess apparently greater power of ascending the wick of the lamp by capillary attraction than is found in ordinary American oils. Taking ordinary petroleum lamp wicks of two different qualities, and using them as siphons, I found that in a given time the following quantities of the oils enumerated were removed by capillary attraction from a vessel into which the wicks dipped, the conditions of the test being the same in each case:—

	Best wick. grs.	Inferior wick. grs.
American oil ("water white")	205·0	104·2
Russian oil	202·6	94·2
American oil (ordinary)	146·0	69·7

Russian oil does not burn equally well in all the forms of lamps which have been constructed for use with the American product, but as the result of a large amount of comparative photometrical testing of the two classes of oils burning in lamps of various construction during the past two or three years, I have formed the opinion that taking the lamps now in common use as a whole, the Russian oil, though giving less light than good ordinary American oil at the commencement of the burning, when the lamp is full of oil and freshly trimmed, affords a flame of somewhat greater permanence, the light emitted in the burning of the American oil diminishing to a greater extent as the level of the oil in the reservoir becomes depressed, the difference being, doubtless, due to the greater power which the Russian oil has of ascending the wick, as already mentioned. In the use of Russian oil, however, it is essential that the air passages in the burner should be quite free from obstruction by dirt, otherwise the flame will receive an insufficient supply of oxygen, will be of comparatively feeble luminosity, and will be liable to smoke. As a rule, the Russian oil burns better in a flat-wick burner than in a round-wick burner, but burners of the latter class are now being constructed in which it yields a good flame.

The astatki, or residuum, as it flows from the kerosene still has a specific gravity of about ·903, and is chiefly used as fuel. A portion of it is, however, converted into lubricating oil, and a smaller portion into an oil or oils similar to the "mineral sperm oil" obtained from American petroleum. Of the lubricating oil the residuum yields about 30 per cent., and of a product similar to the American "Mineral Colza" oil, about 12 per cent. Messrs. Ragosine were the first to introduce an oil of this character made from Russian petroleum. This oil, which is frequently termed "pyronaphtha," as now imported into this country, has a specific gravity of about ·865, a fire test of 265° F., and a flashing point of about 230° F. open test, or 205° F. closed test. This oil, like the similar American product, has not hitherto been much used for domestic purposes, as the lamps intended to burn it did not give a satisfactory light. Lamps are now, however, being introduced which burn it well.

The lubricating oil distillates obtained from Baku petroleum differ from the American products in containing little or no solid hydrocarbons, the greatest quantity obtainable amounting, I believe, only to a quarter of one per cent. of the crude oil. In the Island of Tcheleken there is, however, petroleum to be obtained which yields as much as 6 per cent. of paraffin. This absence of solid hydrocarbons deprives the Baku refiner of a source of profit possessed by the American refiner, but on the other hand enables him to make cheaply a lubricating oil which bears exposure to a very low temperature without becoming solidified or even depositing any paraffin. Professor Dewar has suggested that the products of Baku petroleum may be distinguished from those of American petroleum by exposing them to a temperature sufficiently low to cause the separation of the solid hydrocarbons which are held in solution at common temperatures. Professor Dewar has kindly lent me the series of specimens of Baku petroleum products placed before you.

The lubricating oils manufactured by Messrs. Ragosine, specimens of some of which I am enabled to show you through the courtesy of Mr. E. G. von Glehn, of the Ragosine Company, are termed "oleonaphthas." The specimens shown include the following:—

Extra heavy cylinder oil, sp. gr. ·920.
Cylinder and valve oil, sp. gr. ·912/·915.
Engine machinery oil, sp. gr. ·905/·907.
Dark cylinder oil, sp. gr. ·918/·920.

Russian lubricating oils are characterised by the possession of great viscosity in relation to specific gravity, as is shown in the tabular record, on page 877, of the viscosities of some Russian and American oils of similar specific gravities. The viscosities of a sample of refined rape oil at the temperatures specified are added for comparison. The results are expressed in the number of seconds occupied in the outflow of 50 cubic centimetres from the viscometer I am accustomed to use, and no correction for differences in specific gravity has been made.

It will be noted that the viscosity of the Russian oils is more affected by a rise in temperature, a feature which undoubtedly is a disadvantage, but in the case of both classes of oils the greater the viscosity the greater the diminution in viscosity as the temperature is raised.

I have pointed out that when paraffins are heated to temperatures above their boiling points dissociation occurs and olefines are produced:—

$$C_{20}H_{42} = C_5H_{12} + C_{15}H_{30} = C_7H_{16} + C_{13}H_{26}, \text{ \&c.}$$

At a very high temperature hydrocarbons containing still less hydrogen are produced. This well known fact has been taken advantage of by Mr. Nobel to manufacture from Russian

VISCOSITIES OF RUSSIAN AND AMERICAN OILS.

Temperature Fahr.	1	2	3	4	5	6	7
Degrees.							
50	712½	145	425	1030	2040	2520	—
60	540	105	295½	680	1235	1980	—
70	405	90	225	485	820	1320	—
80	326	73	171	375	580	900	—
90	260	63½	136	262	426	640	—
100	213½	54	111	200	315	440	1015
110	169	50	89½	153	226	335	739½
120	147	47	78	126	174	245	531
130	123½	44¾	63½	101	135½	185	398½
140	105½	41	58	82	116	145	317½
150	95½	37⅓	52	70½	95	115	250
160	85	—	46	63½	83½	93½	200
170	76	—	—	58	70½	77½	161
180	69	—	—	52½	61½	67½	134½
190	64½	—	—	47	56½	61	115⅓
200	58½	—	—	42	48½	54	99¼
210	54	—	—	40	—	—	85
220	50	—	—	38	—	—	77
230	47¼	—	—	—	—	—	70½
240	45½	—	—	—	—	—	64½
250	43¼	—	—	—	—	—	59¼
260	—	—	—	—	—	—	54
270	—	—	—	—	—	—	48½
280	—	—	—	—	—	—	46½
290	—	—	—	—	—	—	44¼
300	—	—	—	—	—	—	42⅗

1. Refined rape oil.
2. American mineral oil, sp. gr. ·885
3. ,, ,, ,, ·913
4. ,, ,, ,, ·923
5. Russian ,, ,, ·909
6. ,, ,, ,, ·915
7. ,, ,, ,, ·884*

petroleum residuum, or astatki, benzene, naphthalene, and anthracene. The process employed consists in breaking up the astatki on the highly heated floor of a cupola regenerative furnace. The first destructive distillation thus effected is stated to yield from 30 to 40 per cent. of tar, containing from 15 to 17 per cent. of 50 per cent. benzol. By a second destructive distillation of the heavy oils remaining after the separation of the benzol, 70 per cent. of tar is obtained, containing from 7 to 10 per cent. of 5 per cent. benzol, 16 per cent. of naphthalene, 2 to 3 per cent. of dry "green grease" (or 30 per cent. anthracene), and 24 per cent. of pitch. There is also obtained in the process 75 to 100 cubic feet, per c.f. of astatki, of gas having an illuminating power described as five times that of coal-gas.

We have already seen that American petroleum oil is principally transported in barrels and cases. As, however, suitable timber for barrel making is scarce in Russia, Mr. Nobel found it necessary to devise some other method of distributing the oil, and great credit attaches to him for the admirable system of bulk transportation he has organised. The oil is pumped from the refineries at Baku into tank steamers on the Caspian sea. These steamers, which were constructed at Motala, in Sweden, are about 250 ft. in length by 28 ft. beam, and have a draft of water when loaded of 10 ft. to 12 ft. The whole of the forward portion of the vessel forms one great tank, the engines and boilers are amidships, and two cylindrical tanks are placed aft. The oscillation of the oil in the forward tank is prevented by bulkheads. The tanks hold collectively 225,000 gallons (5,500 barrels), and can be filled in 4½ hours. The fuel used for steam generation is petroleum residuum, 29 tons being consumed on the voyage from Baku to the mouth of the Volga, a distance of about 460 miles. The engines are of 120 horse-power nominal, and the mean speed of the vessels 10 knots per hour. Several tank steamers have recently been constructed for the shipment of petroleum oil in bulk from Batoum to ports on the Black Sea, the Baltic, and elsewhere. These vessels are built on the principle of the boilers and engines being placed in the stern, and the oil storage tanks forward. Two bulkheads with water between prevent the possibility of any oil finding its way into the boiler space. The steamers are constructed throughout of Bessemer steel, and have been favourably classed at Lloyds.

In the tank steamers described, the oil is conveyed to the mouth of the Volga, where in consequence of the water being shallow, it is transferred to tank barges, in which it is carried to Tsaritsin, an important storage centre on the Volga, 364 miles from the point at which the steamers discharge. At Tsaritsin the oil is pumped into tank waggons (similar to those used in America) on the Tsaritsin-Griazi railway, and thus finds its way to a large number of storage centres throughout Russia. From these centres the oil is distributed in barrels which can easily be returned to be refilled.

A considerable quantity of the oil is also conveyed from Baku to Batoum, on the Black Sea, over the Trans-Caucasian railway, in tank waggons, a distance of 560 miles, but the carrying capacity of this line is only about one million and a half of barrels per annum, in consequence of its being carried over a pass (the Suram Pass) 3,000 feet above sea level, where the gradient is in places as much as 1 in 22. It is contemplated to largely increase the carrying capacity of the line by tunnelling the pass, and it has also been proposed to lay a pipe line from Baku to Batoum. In the meantime, however, arrangements are being completed to fully utilise the existing facilities by shipping the oil from Batoum in tank steamers, and, as the Volga navigation is closed in winter, there is no doubt that the Trans-Caucasian route will be largely made use of.

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* Semi-solid at common temperatures.

I have already given a list of certain kinds of crude petroleum which I have had occasion to examine in the course of the past fifteen years, and I have pointed out the great variation in physical characters which the series exhibits. In the following Table the equally varied yield of commercial products is shown :—

	Naphtha.	Burning Oil.	Lubricating Oil.
	Per cent.	Per cent.	Per cent.
Persia (sp. gr. ·777)	1·4	87·5	—
East India (,, ·821)	3·6	62·5 (sp. gr. ·800)	32·0
Kyouk Phyou, Burmah (,, ·818)	none	55·7 (,, ·800)	31·3
Minbyin, Burmah (,, ·866)	none	15·1 (,, ·810)	65·9
Western Barangah, Burmah (,, ·888)	none	7·2 (,, ·815)	89·3
,, ,, (,, ·835)	2·5	66·1 (,, ·810)	27·3
Assam (,, ·933)	none	none	94·2
India (,, ·935)	none	20·0 (sp. gr. ·805)	60·0
Russia (,, ·836)	20·0	40·0	37·5
,, (,, ·942)	none	none	90·0
Hanover (,, ·843)	10·0	60·0 (sp. gr. ·812)	27·5
South America (,, ·852)	none	50·0 (,, ·808)	45·0
,, (,, ·900)	none	none	91·5
New Zealand (,, ·828)	none	60·0 (sp. gr. ·808)	38·0
Italy (,, ·787)	45 0	45·0 (,, ·806)	5·0
United States, Wyoming (,, ·911)	2·5	27·5	57·5
,, ,, (,, ·945)	none	10·0	72·5

The petroleum from Upper Burmah is very rich in paraffin. On the table I have some specimens of paraffin in the crude state, manufactured from Yenangyoung petroleum in Rangoon, which have been given to me by Messrs. Henry Hill and Sons.

(To be continued.)

Miscellaneous.

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COLONIAL AND INDIAN EXHIBITION.

THE INDIAN SCREENS.

PART I.

The arrangement of the Indian collections in the Art Ware Court is based on topographical position, and the visitor is thus at once able to compare the various styles of art existing throughout the Empire. It is proposed in the present notice to describe the screens which divide the courts the one from the other, and which form a double façade down the central gallery; leaving for a future article the many examples of Art Ware which the court contains. These screens give a good idea of the various styles of carving in wood and stone met with in India, and—so far as the limitations imposed by the Exhibition arrangements permit—a fair notion of the details of the different styles of Indian architecture.

Acting on the principle which left to each Colony participating in the Exhibition the organisation and treatment of its own section, the design of each screen was entrusted to the province which contributed it, the only limitation being as regards length and height. Although this plan has resulted, in parts, in somewhat incongruous combinations, yet it cannot but be felt that greater harmony in the scheme of the two façades would have caused a corresponding loss of individuality in the screens. In a five minutes' walk we may here see upwards of fifty different styles of Eastern art.

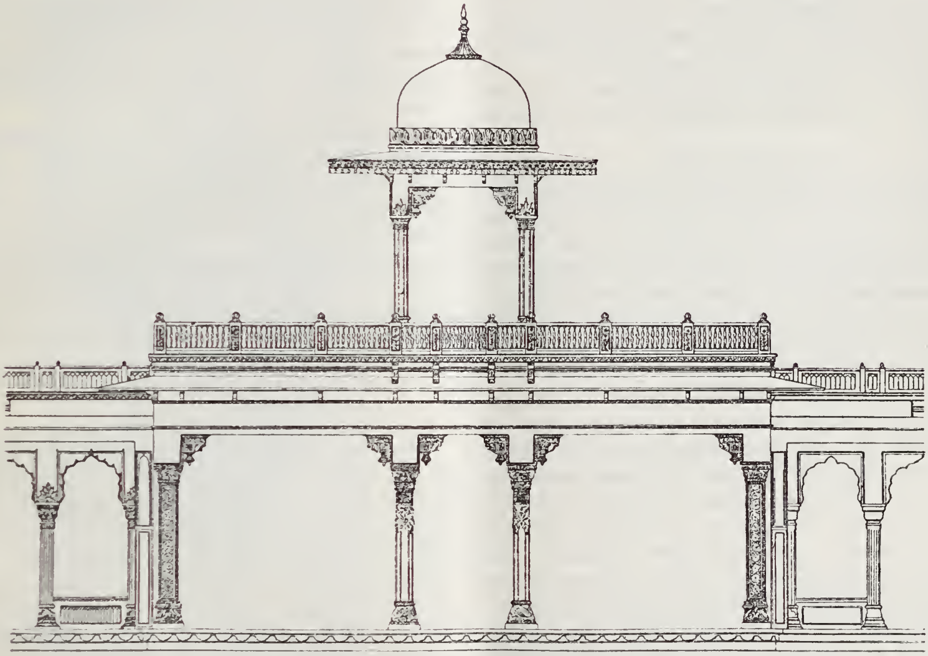
The following account of the screens, to which reference has already been made (*ante* p. 462), are taken principally from the descriptions in the official catalogue published by the Royal Commission, which were supplied from the various Indian provinces. They are described from east to west.

The full-page illustrations to this notice, produced by Mr. Griggs, are taken from the "Journal of Indian Art," which is devoted exclusively this year to the art of the Indian Empire at the Exhibition. The representation of the Baroda pigeon-house has kindly been lent by Messrs. Clowes and Son, from the "Official Guide."

THE JEYPORE GATEWAY.

The courts are entered through a gateway, contributed by his Highness the Maharaja of Jeypore, and carved by his subjects, Shekhawati carpenters. The gateway is surmounted by a Nakar-khana, or drum-house (from the Arabic *Nakara*, a kettle-drum), such as is usually found over the entrance to royal residences or temples. It is used by musicians who play in honour of the sovereign or god.

In the kiosk on the top are arranged all the musical instruments which are usually played in a drum-house, and on the platform are grouped life-size representations of the musicians. On the front of the platform has been carved the Shamsha, or picture of the sun, which is symbolical of the descent of the lords of Jeypore, and of the Rajput chiefs of the solar race.



JEYPORE PAVILION AND SCREEN, RAJPUTANA.

On the opposite side will be found a representation of the moon, from which the Chandrabansi, the other great branch of the Rajput race, represented by the Rajas of Jeysulmere and Karauli, are said to have sprung. On the same beam below the cornice on the front of the gate is engraved the motto of the Jeypore house, *Yato dharm stato jaya*, in Sanskrit, with Latin (*Ubi virtus ibi victor*) and English versions. On the corresponding beam at the back, is seen the motto, *Ex Oriente lux*.

The above illustration affords but an indication of the form of the gateway; the lithograph of the head of one of the arches gives a good idea of the style of the carving.

RAJPUTANA.

From the twenty States forming Rajputana, eight screens are contributed.

Jeypore.—This screen has coloured panels of mythologic subjects for which Jeypore is celebrated, fitted into the horizontal portion. The general design is the modified Saracenic in vogue in Upper India and Rajputana. The only instructions issued to the wood carvers were, that as great a variety of patterns should be employed as possible, the ornament to be purely Indian, and no attempt to be made to work on other than traditional lines.

Bhartpur, Karauli, and Dolphur.—This screen is made throughout of red sandstone procured from the celebrated quarries in the immediate vicinity of the city of Karauli; it was constructed entirely by local stonemasons and stone-carvers, under the general supervision of the State Public Works Department. The style of architecture can not be exactly defined, as the screen is in reality a mixture of copies of parts of several local buildings, fitted to the dimensions required.

Jodhpur.—This screen is carved in teak wood; it was designed and made at Jodhpur by native artists and workmen. The architecture is the modified Delhi adopted in Rajputana.

Ulwar.—The front consists of panels of white marble, from the celebrated quarries of Makrana, perforated and carved in relief, fitted in a framework of black marble, and supported upon three beautifully-carved white marble pillars. A decorative design of glass-work, on which the crest and arms of His Highness the Maharao Raja are emblazoned, surmounts the whole. The designs of the pillars and panels are taken from carvings existing in the Ulwar Palace, and are of pure Hindu style. The glass-work decoration is also taken from the Ulwar Palace. The screen is altogether of Ulwar workmanship.

Kotah.—This screen consists of a front and side piece made of shisham wood (*Dalbergia sisu*) and inlaid with ivory. This style of work is much practised in the town of Etawah in the Kotah State. The architectural design, which is Hindu, has been copied from old buildings in the city of Kotah. The whole screen may be judged by the example which will be given with the second part of this article.

Ajmere.—This screen is designed to represent a sample of the ordinary street architecture in Ajmere city. The archways or arcades are similar to those used in verandahs of houses, *serais*, and shop fronts. These arcades are often surmounted by a system of ornamental bracketing and open carved work, supporting upper balconies. The materials generally used in street architecture of this kind are a mixture of cut stone and stone masonry and plaster work, the whole being either whitewashed or decorated by painting in bright watercolours. This model is carved in wood and painted white to represent the original type as nearly as possible.

Bikanir.—This screen of wood is constructed to show to the best advantage a style of decoration applicable to wood, stone, earthenware, ivory, and glass, and believed to be peculiar to Bikanir. The following brief description may not be uninteresting:—On the surface of the wood, which had been previously well scrubbed with liquid clay and allowed to dry, the outlines of a flower pattern were stencilled with a bag of powdered charcoal through perforated paper. Successive layers of liquid clay were then applied with small squirrel's-hair brushes within the outlines of the pattern, each layer being allowed to dry before the next application, until a raised surface bringing out the stalks, leaves, and petals with sufficient distinctness, had been produced. The whole surface was then fixed by a coat of paint, and when this was dry, gold leaf was applied over all. The ground work was then painted in, the flower pattern standing out in gilt relief.

CENTRAL INDIA.

On the north side, the Central India screen consists of three bays, intended to illustrate both Buddhist and Hindu sculptures as found in Central India. The pillars are modelled on, though not exactly copied from, sculptures existing at Khajurahu, in Bundelkhand. The centre is occupied by an image of Ganesh, the elephant-headed son of Shiva. The bays flanking this central gateway show examples of Gwalior stone carving in relief. These pillars are of simpler style than the central pair, but are also modelled on the carvings of Khajurahu. Some of the stone panels and plaques are copied from the Sanchi Tope, near Bhopal, and from the Fort at Gwalior, which was restored to the late Maharaja Scindia shortly before his death.

On the south side the style of screen is altogether lighter. Here, again, there are three bays. The side portions are fitted with glazed tiles. One flanking bay is fitted with perforated stonework from Gwalior, and the other with perforated wood-carving from Ujjain. The three pairs of pillars are copied from those often seen in temples and dwelling-houses in Indore and its neighbourhood. As an example, a base of one of these pillars will be given with the second part of the article.

BOMBAY.

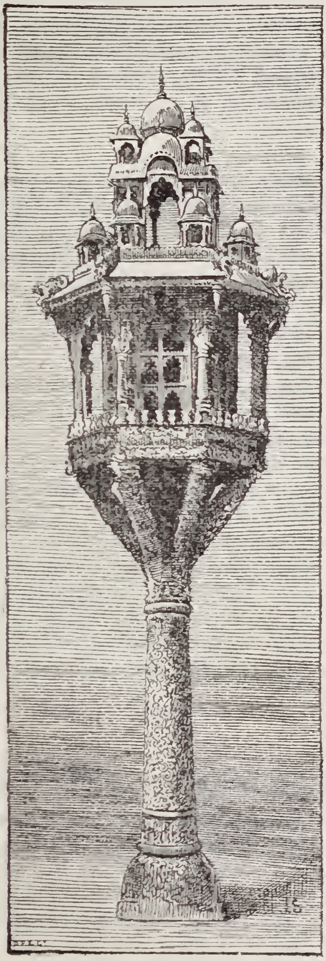
The screen, the general design for which was made by Mr. Griffiths, the Superintendent of the Bombay School of Art and Secretary to the Bombay Committee for the Exhibition, consists of two lengths, each 80 feet long, made up of eight open bays. In addition to these are the four ends, the total length of the screen being 208 feet, with a uniform height of 10 feet. It was designed with a view to illustrate as fully as possible the wood-carving characteristic of the Presidency.

The sections belonging to the Royal Commission, to His Highness the Gaikwar of Baroda, and to His Highness the Rao of Cutch, were executed by native artisans under the superintendence of Mr. Wimbridge, of the East India Art Manufacturing Company, Bombay. The carved details for the Royal Commission and Cutch sections were selected by Mr. Wimbridge from mosques at Ahmedabad, and the detail for the Baroda section from various houses in Surat. The illustration of a portion of this screen, which will be given with the second part of this article, amply proves its beauty of design and richness of detail.

The Bhavnagar section, which comprises four of the richest bays, was constructed in Bhavnagar itself, under the immediate supervision of Mr. Proctor Sims, the state engineer. The details of the work are taken from the old palace and from some of the old houses in the town.

The details of the other screens in this court, selected from the ancient mosques (built towards the end of the 15th and the beginning of the 16th century) of the city of Ahmedabad, once the greatest in Western India, illustrate the action of Mohammedan influence upon the Hindu style. The work is executed in teak. Plaster casts of the panels and pillar in this screen have been taken by the Royal Commission for the decoration of nearly the whole of the private Exhibitors' Court.

The Baroda Pigeon House.—The Baroda pigeon house, a lofty structure, most elaborately carved, presented by H.H. the Gaikwar of Baroda, has, for the sake of convenience, been removed from the Bombay Court, and placed in the centre of the gallery to mark, the turning to the central courts of the Exhibition. The four smaller pigeon houses, which were intended to be placed around its base, have, however, been left in the Bombay Court. In Baroda and throughout Gujarat, the inhabitants erect pigeon houses for feeding not only pigeons, but parrots, sparrows, and all birds living in or near their towns. The Gujeratis consider it a sin to kill any animal, and to feed them is held to be a great act of charity. Pigeon houses, therefore, are erected by the wealthy natives from motives of piety. The accompanying illustration gives an idea of the general design; the detail of the carving is somewhat similar to that of the Baroda screen.



(*To be continued*).

STATUES OF COLONIAL WORTHIES.

BY J. S. O'HALLORAN,

(*Continued from p.* 865.)

WEST INDIES.

CHRISTOPHER COLUMBUS, the famous navigator, born 1546, dicovered Jamaica, the Bahamas, and other groups in 1592-94. The original model of a bronze statue, by D. Chidoni, of Milan, surrounded by emblematical figures of the savage and civilisation, navigation and geography, may be seen in the West Indian Court of the Colonial and Indian Exhibition. A marble statue of Columbus was erected in Genoa in 1862, and stands on a pedestal adorned with ships' prows; at the feet of the statue, which rests on an anchor, kneels the figure of America. The monument is surrounded by allegorical figures representing religion, geography, strength, and wisdom.

HONG KONG.

SIR ARTHUR KENNEDY, K.C.M.G., C.B., was Governor of the colony from 1872 to 1876. A photograph of a bronze statue, by M. Raggi, which will shortly be erected in the public gardens, is on view in the Hong Kong Court of the Colonial and Indian Exhibition.

STRAITS SETTLEMENTS.

SIR THOMAS STAMFORD RAFFLES was born in 1781, and died in 1826. Selected at an early age to administer the government of the British colonies in the Indian Ocean, he raised Java to a condition of prosperity and happiness which was unknown under previous rulers. After the surrender of that island to the Dutch, and during the period of his government of Sumatra, he founded an emporium at Singapore, where he established a free post, and secured to the British flag the maritime ascendancy of the Indian seas. A statue by Chantrey is in Westminster Abbey, and Thomas Woolner, R.A., has completed a model in clay, which is about to be cast into bronze for erection in Singapore. It is 9 feet in height.

CEYLON.

GENERAL SIR EDWARD BARNES, K.C.B., administered the government of Ceylon from 1820 to 1822, and from 1824 to 1831. There is a statue to his memory at Colombo.

RIGHT HON. SIR WILLIAM GREGORY, K.C.M.G., Governor of Ceylon from 1871 to 1875. Statue at Colombo.

SIR HENRY WARD, K.C.M.G., Governor of Ceylon from 1855 to 1860. Statue at Kandy.

MAURITIUS.

MAHE DE LABOURDONNAIS was Governor of the island from 1734 to 1746. Under his able administration, the cultivation of the sugar-cane was introduced and the foundation of its future prosperity was laid. A bronze statue was erected to his memory in 1859 as a tribute from British subjects to one who governed the island before it became a British colony. Facing the landing place "it greets the eye as you step on shore, and it does not need much stretch of the imagination to fancy he is welcoming the stranger to the shores for which he spent so many years of untiring devotion."

SIR WILLIAM STEVENSON, K.C.B., governed the colony from September, 1857, to January, 1863, and shortly after his death a statute to his memory was placed in the Quadrangle at Government House, Port Louis.

GIBRALTAR.

LORD HEATHFIELD rendered important services to his country by his gallant defence of Gibraltar—of which colony he was governor—against the combined attack of the French and Spanish forces on September 13th, 1782. He died July 6th, 1790. Statue at St. Paul's Cathedral, by Charles Rossi.

CAPE OF GOOD HOPE.

SIR GEORGE GREY was Governor from 1854 to 1861. He was previously Governor of South Australia, and subsequently of New Zealand, in which colony he now resides. His statue stands in the Botanic Gardens at Cape Town, and faces the Grey Library, containing a valuable collection of rare books and manuscripts which he presented to the colony.

The **RIGHT HON. SIR BARTLE FRERE, Bart.**, Governor and High Commissioner from 1877 to 1880, was an able and experienced administrator, who had served his country during a lengthened and active career in India. Although his South African policy has been freely criticised, recent events have largely contributed to endorse its wisdom. Throughout his career he earnestly sought to maintain the honour of his country and the integrity of the empire. He died in 1884, and was accorded a public funeral at St. Paul's Cathedral. A bronze statue, by Thomas Brock, A.R.A., will shortly be erected on the Thames Embankment, at the foot of Northumberland-avenue, as a tribute of respect and general esteem.

WEST AFRICA.

WILLIAM WILBERFORCE, GRANVILLE SHARP, THOMAS CLARKSON, whose names will ever be specially identified with those exertions which removed from England the guilt of the African slave trade, and prepared the way for the abolition of slavery in the Empire. The two first-named philanthropists were amongst the first proprietors of the Sierra Leone Company, which was incorporated in 1791. A statue of William Wilberforce—born 24th August, 1759, died 29th July, 1833—is in Westminster Abbey, Joseph, sculptor. There are busts of Granville Sharp and Clarkson in the Guildhall, London.

Space does not here permit of an enumeration of the various statues of distinguished Anglo-Indians which have been erected in India and in this country, and include the work of some of our leading sculptors.

Any account of statuary in relation to the Colonies would, however, be incomplete without a reference to the large number of representations of her Majesty the Queen which are to be found in the British Colonies, and which give outward expression to that sentiment of loyalty to the throne by which all colonists are alike animated.

The information contained in this article is derived from personal observations in various parts of the British Empire, supplemented by a somewhat voluminous correspondence. As the subject embraces so wide a scope that it is obviously impossible for any one writer to deal with it exhaustively, the author indulges in the hope that his Colonial friends will kindly supply such further notes as will serve to make complete what is admittedly an imperfect sketch.

MEETINGS FOR THE ENSUING WEEK.

The following are Conferences for the week ending July 17th, at the Colonial and Indian Exhibition:—

MONDAY, JULY 12...Sir Robert Biddulph, "Cyprus." 4 p.m.

TUESDAY, July 13 ... Conference of the Anthropological Institute. "Races of the Straits Settlements and Borneo." 4 p.m.

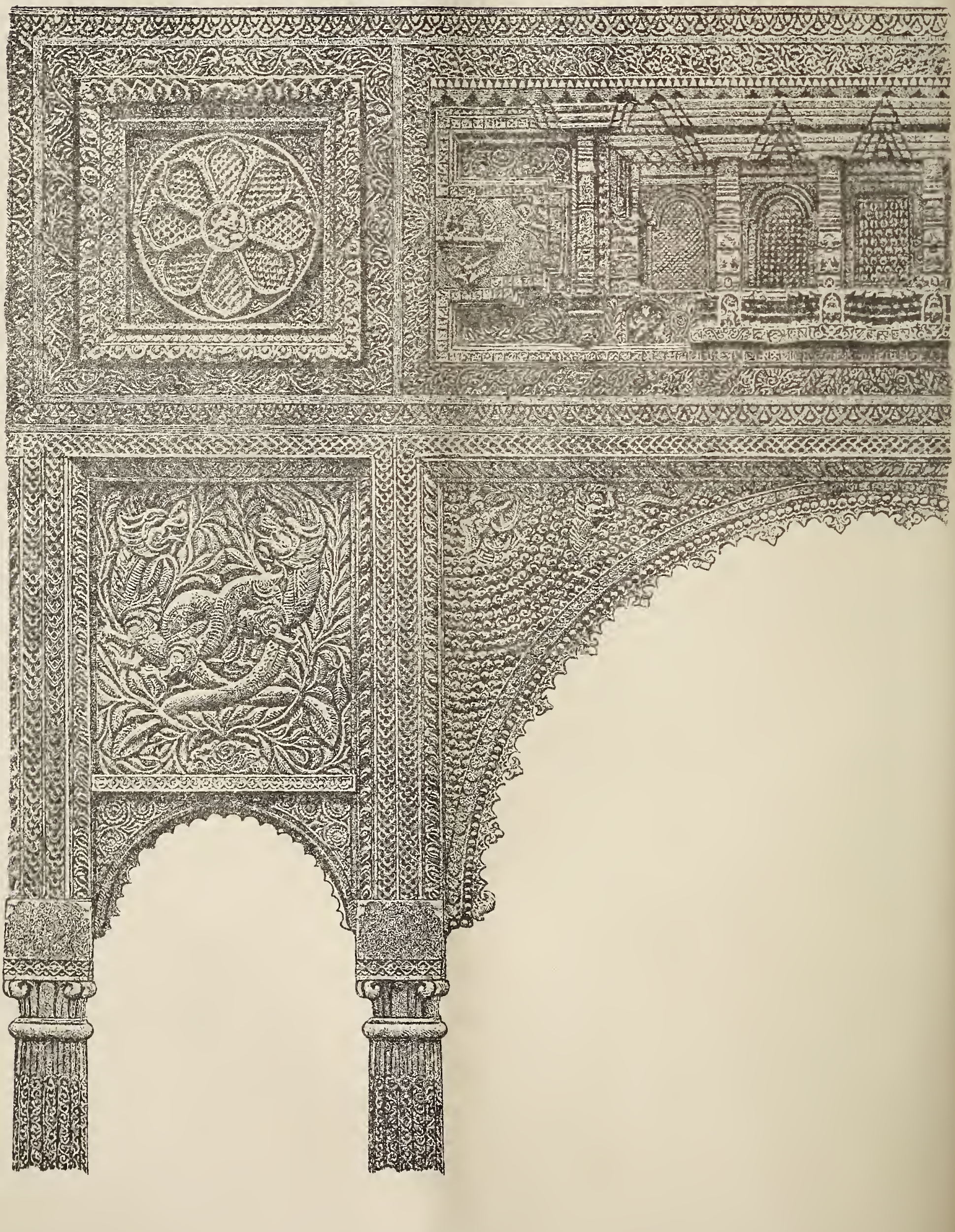
WEDNESDAY, JULY 14...Prof. Leone Levi, "Wages of Labour in relation to Cost of Living." 4 p.m.

THURSDAY, JULY 15...G. Wall, "Capabilities of Ceylon." 4 p.m.

FRIDAY, JULY 16...Dr. Brandis, "The Forests of India." 3 p.m.

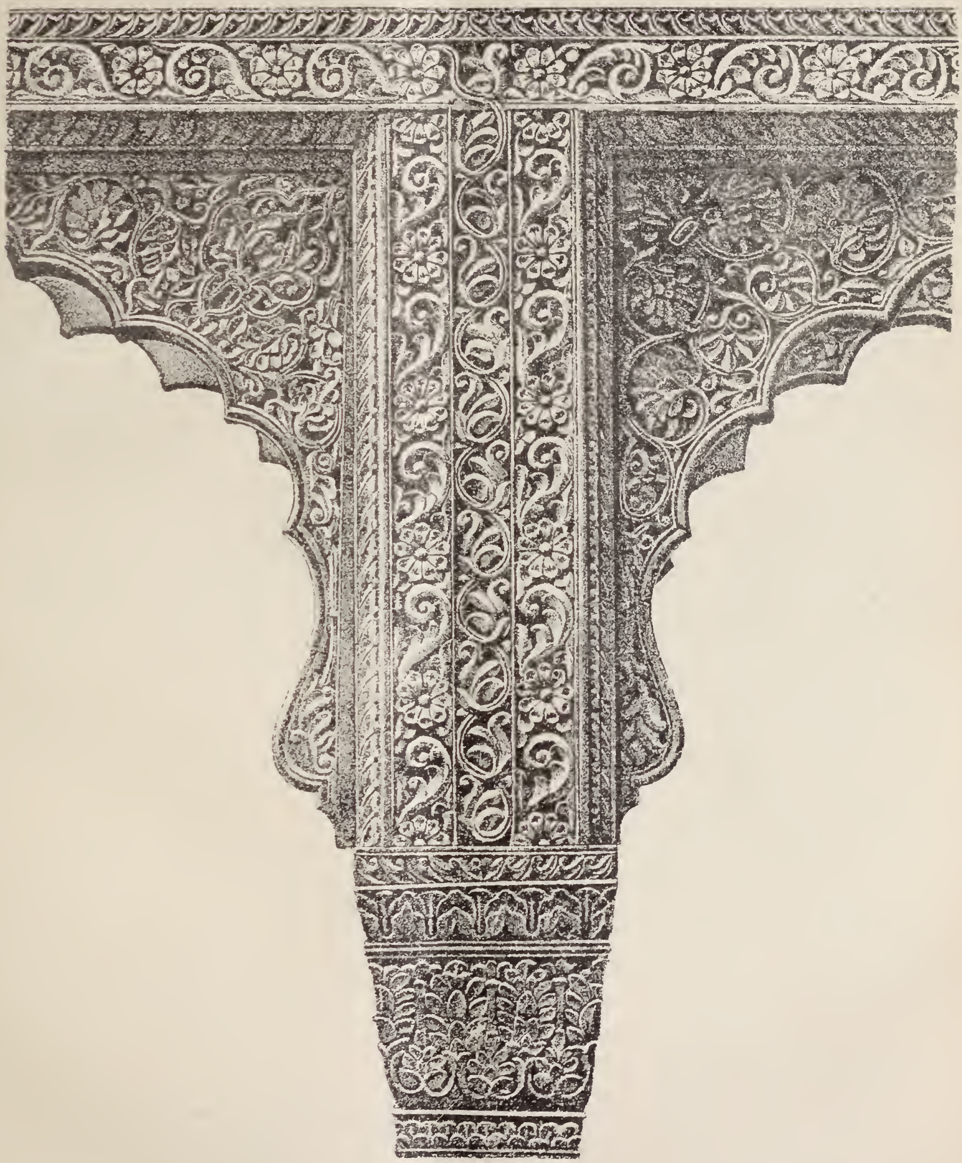
SATURDAY, JULY 17...Conference of the Geologists' Association. "New Zealand." 3 p.m.

SUPPLEMENT TO SOCIETY OF ARTS JOURNAL, JULY 9th, 1886.



DETAIL OF NEPAL SCREEN.

SUPPLEMENT TO SOCIETY OF ARTS JOURNAL, JULY 9th, 1886.



DETAIL OF JEYPORE SCREEN.

Photo-lith. W. Griggs.

Journal of the Society of Arts.

No. 1,756. Vol. XXXIV.

FRIDAY, JULY 16, 1886.

All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

NOTICES.

CHAIRMANSHIP OF COUNCIL.

On Monday last, 12th inst., at their first meeting, the Council elected Capt. Douglas Galton, C.B., D.C.L., F.R.S., as Chairman for the ensuing year. The various committees were also re-appointed.

CONVERSAZIONE.

The Society of Arts' Conversazione will be held, by permission of the Royal Commission of the Colonial and Indian Exhibition, at the Exhibition Buildings, this evening (Friday) 16th July.

Proceedings of the Society.

CANTOR LECTURES.

PETROLEUM AND ITS PRODUCTS.

By Boverton Redwood, F.I.C., F.C.S.

[The right of reproducing these lectures is reserved.]

Lecture III.—Delivered March 22, 1886.

(Continued from p. 878.)

We now enter upon the consideration of the process of manufacturing the various commercial products from shale. True shales, when heated to redness in a closed vessel, do not cake, so that the soft and black residue, after all the volatile matter has been driven off, retains the original form of the fragments. The proportion of mineral matter in the shale is usually 73 per cent., but is occasionally as much as 80 per cent. Mr. Henderson, of the Broxburn Oil Company, to whom, as well as to Mr. Kennedy, managing director of the Company, I am indebted for much valuable information, informs me that the Broxburn shale yields:—

	Per cent.
Crude oil	12·5
Water	8·5
Gas	3·0
Ash	67·0
Carbon in spent shale	9·0
	100·0

In the earlier days of the industry two methods of distillation, one intermittent and the other continuous, were employed. In the former system, which was that first adopted, the shale, previously broken into fragments of suitable size, was heated in cast-iron retorts, similar to those employed in coal-gas manufacture, the retorts being discharged and recharged when the whole of the volatilisable matters had been driven off. The latter system was conducted in a cylindrical or oval retort of cast-iron, about 2 ft. in diameter by 8 ft. or 10 ft. in length, set vertically in a furnace. In this vessel the shale, previously broken by machinery, was exposed to a dull red heat for twelve to twenty hours; a jet of steam being introduced at the bottom of the retort, and the products conducted from the top. The steam was employed to sweep away the products as formed, and prevent their dissociation by overheating. The furnace was so constructed that the lower part of the retort received the greatest heat, and from time to time a portion of the exhausted shale was removed from the bottom of the retort, which was sealed with water, and a corresponding quantity of fresh shale was introduced at the top; the process being thus continuous. By this process about 33 gallons of crude oil and 80 gallons of ammoniacal liquor per ton of shale were obtained, the latter being large in volume and of low strength, in consequence of the condensation of the steam employed.

The method of distillation devised by Mr. Henderson differs principally from the intermittent system already described in the retorts being vertical, and in the provision of an arrangement for employing as fuel the spent shale, which sometimes contains as much as 12 to 14 per cent. of carbon. The retorts are, in this system, placed in an oven above the furnace. They are about 15 ft. in length, and hold about 18 cwt. of shale. The bottom of the retort consists of a door, which can be opened so as to allow the spent shale to drop into a combustion chamber beneath the oven. The material, as it is discharged from the retort, is black, but it soon becomes incandescent, and, aided by the incondensable gaseous products of distillation (occasionally also by the addition of a small quantity of coal), it constitutes a valuable fuel. In this system of distillation the upper part of the retort is the most highly heated, and the products are removed from the bottom, a stream of superheated steam being passed in at the top. There are four retorts in each oven, and each retort is charged once in sixteen hours; but the charging takes place in rotation at intervals of four or five hours, so that a regular supply of fuel is furnished to the combustion chamber below.

Although, in the meantime, the older method of intermittent distillation had been improved, it is generally admitted that the introduction of the Henderson retort resulted in an increased yield of paraffin.

The retort invented by Messrs. William Young and George Beilby, the Pentland pattern of which is now also largely in use, is composite, the upper part being of iron, and the lower of fire brick. In this apparatus the shale is exposed to a comparatively low temperature while in the iron portion—the oil products being thus driven off without risk of their being overheated—and then passing downwards into the more highly heated fire brick portion, in consequence of the withdrawal of a portion of the spent material, is subjected to a heat suitable for the formation of the ammonia. Steam is passed into the retort at the base. The retorts are set in groups of four, and, as I saw them in operation at the Pentland Works, are heated through the medium of a gas-producer instead of by an ordinary open furnace. By this method of distillation the yield of paraffin is increased, while the gain of sulphate of ammonia is stated to be no less than 14 lbs. per ton of shale.

The oil vapours are condensed by being passed through a series of 70 to 100 vertical 4 in. pipes.

Crude shale oil is of a dark green colour, and has a specific gravity of ·865 and upwards. The first step in the process of refining consists in the distillation of the oil to dryness in cast-iron pot-shaped stills, into which steam, often superheated, is passed, the product being condensed in the manner I have already described when treating of the distillation of petroleum. The oil having been treated with sulphuric acid and caustic soda, these processes being termed "washing," is next subjected to fractional distillation in cylindrical boiler-plate stills of a capacity of 4,000 to 5,000 gallons. Steam is introduced into the stills after the more volatile products have passed off. The first product obtained is crude naphtha, and at a higher temperature the burning oil distillate issues from the condensers and is collected separately. The heavy oil which remains is distilled in cast iron vessels. The burning oil distillate thus produced is subjected to acid and alkali treatment, and undergoes a second fractional distillation, an additional quantity of naphtha being separated, and some heavy oil remaining in the still. The burning oil distillate then passes through a third chemical treatment and distillation, and is, in some cases, finally agitated with acid and alkali, and thoroughly washed. The crude naphtha receives the usual chemical treatment, and is separated by fractional distillation into commercial products. From the heavy oil lubricating oils are manufactured, and paraffin separated and purified substantially as in the case of the similar petroleum products. It was formerly the practice to crystallise the paraffin rapidly, by bringing the heavy oil into contact with the surface of a revolving drum through which cooled calcium chloride solution was made to circulate, the paraffin adhering to the cool surface being scraped off and removed. Mr. Henderson, and subsequently Mr. Beilby, however, patented systems of slow cooling in considerable bulk, similar to that which I have described as being adopted in petroleum refineries in the United States. Various other systems have been adopted at Addiewell and Bathgate for the slow cooling of the oil containing paraffin, it being now generally recognised that the production of large crystals of paraffin resulting from this method of working facilitates the expression of the oil, and effects a saving in press cloths. From the gaseous products passing away through the condensers crude gasoline is obtained, by a process of scrubbing with heavy oil in a coke tower, or by subjecting the gas to pressure. The crude gasoline passes through a similar process of purification to that which the crude naphtha undergoes.

From the intermediate oils burning oils of high specific gravity and flashing point are obtained.

Without going minutely into details of manufacture, which are by no means the same at all works, I have endeavoured to give an intelligible outline description of the comparatively lengthy and complicated process by which the various shale products are obtained. In practice, the various similar distillates obtained in the intermediate operations are mixed together, the process, as a whole, having for its object to classify the various hydrocarbons by successive fractional distillations. It should be stated that the crude shale oil yield, in addition to the products enumerated, acid and basic bodies.

At the works of Young's Paraffin Light and Mineral Oil Company, the following is the average yield of the various commercial products from the crude shale oil:—

	Per cent.
Gasoline	0·25
Naphtha—sp. gr. ·700 to ·760	5·75
Burning oils—	38·00
No. 1, sp. gr. ·802 to ·804, F.P. 110° (Abel test)	
No. 2, sp. gr. ·810 to ·812, F.P. 100° (Abel test)	
Crystal (No. 1 chemically treated)	
Lighthouse oil, sp. gr. ·810 to ·820 F.P. 140° (Abel test)	
Lubricating oils of various specific gravities	14·50
Paraffin (solid)	11·00
Loss	30·50
	100·00

The per-centages given are only approximate, and are often purposely varied by alterations of the processes to suit the requirements of the markets. The loss is no doubt frequently considerably smaller than the proportion stated.

At the Broxburn works the average yield is as follows:—

	Per cent.
Naphtha—sp. gr. ·730	5·00
Burning oils:—	
Petroline—sp. gr. ·800/·802	37·28
No. 1 oil—sp. gr. ·808/·810	
Lighthouse oil—sp. gr. ·810	
Lubricating oils	17·40
Solid paraffin	12·52
Loss	27·80
	100·00

Mr. John Fyfe, managing director of Young's Company, has kindly supplied me with the interesting collection of shale oil products on the table, and with much valuable information in regard to the processes of manufacture.

A process for the continuous distillation of shale oil was patented by Mr. Henderson in 1883. I am informed by Mr. Kennedy, of the Broxburn Oil Company, that Mr. Henderson's process is in successful operation at the works of that company, and is giving very satisfactory results.

Mr. Alfred H. Allen, in his "Commercial Organic Analysis," a work containing much useful information on the chemistry and examination of mineral oils, asserts that shale-burning oil contains about 36 per cent., by measure, of paraffins, and 64 per cent. of olefines and other hydrocarbons acted on by fuming nitric acid; while in American refined petroleum (burning oil) these proportions are reversed; and he gives the following comparative statement, based upon the relative per-centages, by measure, of hydrocarbons present in the various commercial products which withstand a consecutive treatment with nitric acid, 1·45 specific gravity, concentrated sulphuric acid, fuming sulphuric acid, and caustic soda; remarking, however, that the quantitative composition is liable to considerable variation, and hence must not be interpreted too literally:*—

NAPHTHA.

From Shale.—At least 60 to 70 per cent. of heptylene, C_7H_{14}, and other hydrocarbons of the olefine series, C_nH_{2n}. The remainder paraffins, C_nH_{2n+2}. No trace of benzene or its homologues.

From Petroleum.—At least 70 per cent of heptane, C_7H_{16}, and other hydrocarbons of the paraffin series, C_nH_{2n+2}. The remainder apparently olefines, with distinct traces of benzene, C_6H_6, and its homologues.

BURNING OIL.

From Shale.—50 to 80 per cent. or more, of the higher members of the olefine series, C_nH_{2n}. The remainder paraffins, C_nH_{2n+2}.

From Petroleum.—50 to 80 per cent. of the higher members of the paraffin series, C_nH_{2n+2}. The remainder chiefly olefines, C_nH_{2n}.

LUBRICATING OIL.

From Shale.—Chiefly olefines, C_nH_{2n}, with some polymerised members of acetylene series, C_nH_{2n-2}.

From Petroleum.—A large proportion of higher olefines, C_nH_{2n}; but less than in corresponding shale product.

VASELINE.

From Shale.—No such product.

From Petroleum.—Chiefly higher paraffins of low melting point.

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* I may remark that, especially as regards the burning oil made from American petroleum, the proportion of olefines present depends upon the extent to which the process of "cracking" has been adopted, as I have already explained.

PARAFFIN WAX.

From Shale.—Solid paraffins, C_nH_{2n+2}.

From Petroleum.—Solid paraffins, C_nH_{2n+2}.

Instead of acting on the olefines by nitric and sulphuric acids as described, bromine may be used to effect their separation from the paraffins, and a process of analysis based upon this fact has been devised by Mr. Allen.

Mr. J. J. Coleman found that the liquid obtained on subjecting the gaseous products of shale distillation to cold and pressure, consisted chiefly of olefines:—Butylene, C_4H_8; amylene, C_5H_{10}; and hexylene, C_6H_{12}.

The following results, obtained by Mr. Galletly with paraffin from Boghead coal, show that the specific gravity of this product increases with its melting point:—

Specific gravity.	Melting point.
·8236	89·6° F.
·8480	102·2° ,,
·8520	104·9° ,,
·9090	128·0° ,,
·9110	128·0° ,,
·9243	136·4° ,,
·9248	138·2° ,,
·9400	176·0° ,,

The ozokerit, separated by melting from the earthy matter with which it is associated, and purified by treatment with Nordhausen oil of vitriol, has a deep yellow colour, and in that condition is stated to be used as an adulterant of beeswax. To obtain a material suitable for candle making, it has, however, hitherto been necessary to subject the ozokerit to distillation in a current of superheated steam, the products being about 5 per cent. of gaseous hydrocarbons, 3 per cent. of naphtha, 6 per cent. of semi-solid "ozokerine," 12 per cent. of soft paraffin (melting point 44½° to 46° C.), distilled ozokerit (melting point 61° C.), and a black waxy residue. The greyish coloured distilled ozokerit thus obtained is refined by a process similar to that which paraffin from petroleum or shale undergoes. The refining of ozokerit is carried out on a large scale by Messrs. J. C. and J. Field, to whom I am indebted for the samples on the table.

I have already referred to peat as a source of mineral oils and paraffin. About the time when Mr. James Young laid the foundation of the present shale oil industry, Mr. Reece Reece and Sir Robert Kane were working upon Irish peat, and Sir Frederick Abel has stated that in 1851 or 1852 he saw some small candles made from peat paraffin. According to Dr. Edmund J. Mills, peat furnishes from 3 to 6 per cent. of tar, the specific gravity of which is about ·954, and Vohl states that peat tar yields, on the average, about 20 per cent. of burning oil (specific gravity ·82), and about 22 per cent. of lubricating oil. The per-centage of paraffin appears to vary considerably, as it is placed by different writers at from 0·1 per cent. to 3·4 per cent.

It will be interesting at this point to consider, briefly, the extent of the world's consumption of mineral illuminating oils. We find that the estimated total out-turn by all the refineries in the United States, for the year ended December 31st, 1885, was 732,650,628 American gallons, or 14,365,698 barrels of 51 American gallons (equal to about 40 imperial gallons). The approximate home consumption in the United States amounted to about 253,665,075 American gallons, or 4,973,825 barrels; and the quantity exported was 5,381,099 barrels, and 17,254,611 cases, collectively equal to 446,982,159 American gallons. The detailed shipping statistics give the respective quantities for the year 1885 as 6,985,637 barrels, and 16,528,844 cases, a discrepancy which may be due to differences in dates. On the latter basis, the total gross weight of the barrels would be 1,222,486 tons. If piled six high, as they commonly are when stored, the barrels would cover a space of about half a square mile, and if placed end to end would extend for a distance of 3,638 miles. The tin-plate used in the manufacture of the cases amounts to nearly 38,502 tons, and would cover more than five square miles, and 431 acres.

The burning oil manufactured in Baku during the year 1885 amounted to 27,000,000 poods, equal to 118,800,000 imperial gallons. Of this, about 17,000,000 poods were consumed in Russia, and about 5,000,000 poods, equal to 22,000,000 gallons, were exported, leaving a balance of 5,000,000 poods in stock at the end of the year. We have thus a total of over 700,000,000 gallons of burning oil manufactured per annum in the United States and Russia; to this the similar products manufactured at the refineries on the continent of Europe and in Scotland have to be added.

We have seen that petroleum consists of a mixture of hydrocarbons, varying in volatility, and that the line of demarcation between petroleum spirit and petroleum oil is a purely arbitrary one, there being but little difference between the inflammability of the least volatile hydrocarbon present in the spirit and the most volatile in the oil on the one hand, and between the most volatile hydrocarbon present in the still heavier product and the least volatile in the oil on the other hand. The presence of too large a proportion of the denser products prevents the oil from burning freely; while the presence of an undue proportion of the hydrocarbons of lower boiling point renders the oil unsafe for use in ordinary mineral oil lamps. At an early period in the development of the mineral oil industry, attention was accordingly directed to the necessity of drawing such lines of demarcation as would insure the supply to the consumer of an oil of satisfactory character. The specific gravity of the product was found to afford a sufficient indication of the amount of the denser hydrocarbons present, but not of the inflammability of the product, since a percentage of the more volatile hydrocarbons, too small to materially alter the specific gravity of the oil, was found to be sufficient to produce an inflammable atmosphere in the oil reservoir of the lamp. It was, therefore, obviously necessary to apply a special test to determine the inflammability of the liquid. The earliest attempts in this direction took the form of pouring the oil on to water heated to a given temperature, passing a light over the surface, and noting whether the oil evolved inflammable vapour or itself ignited, the temperature at which the oil first gave off enough vapour to ignite being termed its "flashing point," and that at which it caught fire its "fire test."

Subsequently, special apparatus were constructed for the more convenient application of this test, the principal of which I will presently describe.

After some years of experience, it was found that the testing of the oil in an open cup was attended with certain disadvantages, and various forms of closed cup were introduced.

The greater number of the petroleum testing instruments employed at the present time, and all those whose use is prescribed by law may be divided into the two classes referred to, viz., those which have an open cup and those in which the oil cup is provided with a cover, and the use of instruments of the latter class is largely on the increase. It has also been proposed, however, to determine the inflammability of the oil by noting the tension of its vapour at a given temperature, and various forms of apparatus have been devised with this object, but since there is no definite, or at any rate no simple, relation between vapour tension and inflammability, this method of testing has not found favour.

Of the forms of open cup tester, that which is known as Tagliabue's has been very largely used for many years. The apparatus, which is before you, consists of a glass cup containing the oil, placed in a water bath heated by means of a small spirit lamp. A thermometer is suspended in the oil, and the temperature noted at which on passing a burning splinter of wood across the surface of the oil either a flash of ignited vapour is obtained, or the oil itself takes fire. The ignition of the oil is always preceded by a flash, but the number of degrees of temperature through which the oil must be raised between its flashing and igniting varies acccording to the character of the oil.

The English Petroleum Act, passed on the 29th July, 1862, provided that "Petroleum for the purposes of this Act shall include any product thereof that gives off an inflammable vapour at a temperature of less than 100° of Fahrenheit's thermometer," but as the method of testing was not described, the Act was practically inoperative. On the 13th July, 1868, an amending Act was passed, defining "petroleum" for the purposes of the Acts as including "all such rock oil, Rangoon oil, Burmah oil, any product of them, and any oil made from petroleum, coal, schist, shale, peat, or other bituminous substance, and any product of them, as gives off an inflammable vapour at a temperature of less than 100° of Fahrenheit's thermometer." Appended to the Act was a schedule prescribing the form of apparatus and method of testing to be adopted. The apparatus, which I have on the table, consists of a slightly conical oil cup of thin sheet iron, provided with a flat rim, and a raised edge, $\frac{1}{4}$-inch high. Across the cup, and fixed to the edge, is a wire, which is thus $\frac{1}{4}$-inch above the flat rim. The oil cup is supported by the rim in a tin water bath. The water bath having been filled "with cold, or nearly cold," water, the oil cup, supported as described, was filled with the oil to be tested, care being taken that the liquid did not cover the flat rim. A thermometer with a round bulb, and so graduated that every 10° F. occupied not less than $\frac{1}{2}$ in. on the scale, was then placed in the oil so that the bulb was immersed about $1\frac{1}{2}$ in. beneath the surface. A screen of pasteboard or wood of specified dimensions was then placed round the apparatus, and a "small flame" applied to the bottom of the water bath. When the temperature reached 90° F., a "very small flame" was passed across the surface of the oil on a level with the wire, this application of the test flame being repeated for every rise of "two or three degrees" in temperature until a "pale blue flicker or flash" was produced. The temperature was then noted, and the experiment repeated with a fresh sample of the oil, withdrawing the source of heat when the temperature approached that noted in the first experiment, and applying the test flame at every rise of two degrees. Various modifications of the open vessel tester have been devised, especially in the United States.

Arnaboldi's apparatus is similar to Tagliabue's, but is of larger size, and in one form has an adjustable mechanical arrangement for applying the test flame at a prescribed distance from the surface. When I visited the United States in 1870, Messrs. Lockwood Brothers and Holly, petroleum inspectors, gave me the apparatus on the table, which is, as you see, provided with an independent oil lamp, by means of which a test flame can be moved across the testing cup at any required height above the oil surface. In Mr. George M. Saybolt's testing apparatus, which was a few years ago adopted by the New York Produce Exchange, the ignition of the vapour is, as you see, effected by means of an electric spark.

The greater part of the earlier petroleum legislation in the United States was based upon fire test and not upon flashing point; and the present rules of the New York Produce Exchange recognise no other test as the basis of commercial transactions in petroleum oil, but in many of the States the petroleum laws now prescribe a test of flashing point.

One of the earliest forms of closed vessel testers is that of Tagliabue. This is provided with a brass oil cup with a cover, attached to which is a spring valve and dwarf chimney. The opening of this valve, and the simultaneous passing of a small flame into the chimney through a lateral orifice determines a current of air through the upper part of the oil cup, which sweeps out the inflammable vapour and brings it into contact with the flame. The Michigan and Wisconsin States tester has a copper oil cup with a copper cover, provided with a small orifice to which the test flame is applied. The present New York State tester is precisely similar to that last described, except that the oil cup is of large size and has a glass instead of a copper cover to the oil cup. The closed vessel tester employed in Austria is similar in principle to Tagliabue's. Parrish's naphthometer used in Holland is provided with a stationary flame, fed by the oil in the testing cup. The Foster tester is similar in principle. In Millspaugh's tester the oil cup is of glass, and is immersed only to the extent of one-tenth of its depth in the water bath, the object, apparently, being to prevent the overheating of the surface of the oil. Mann's tester represents an attempt to reproduce in the testing apparatus the conditions which prevail in an ordinary petroleum lamp, the burner of the lamp being replaced by a tube, the stopper of which is blown out when, upon the introduction of a flame through a lateral opening, ignition of the vapour occurs. In Pease's closed tester the vapour is ignited by an electric spark.

Professor Arthur H. Elliott, of New York, has recently made a large number of comparative experiments with the various instruments described, and has embodied the results in a report to the New York State Board of Health. I am indebted to Professor Elliott for a copy of this report.

I well remember seeing, about the year 1870, a closed tester, with electric spark arrangement, in use by the late Dr. Letheby in his laboratory at the London Hospital. The oil cup was of glass, and was provided with a hinged metal cover, which was blown open when the vapour was ignited by the spark.

Dr. Attfield has recommended that the flashing point should be taken by warming the oil in a test-tube, and inserting a flame into the mouth of the tube.

Several years ago the late Mr. Keates, in his capacity of chemist to the Metropolitan Board of Works, proposed the use of the simple form of closed vessel tester now before you, this little tin cup which he gave me at the time being, I believe, the one actually used in his earlier experiments.

A Petroleum Bill, which besides amending the law in several desirable respects would have legalised the use of Mr. Keates's tester, was introduced into Parliament in 1871, but in consequence mainly of the test standard being fixed at a point (85° F.) which was higher than the equivalent of the existing test standard, the Bill was opposed by the petroleum trade, and the proposal to change the method of testing withdrawn. The Bill passed on the 11th August in that year, repealing the two previous Acts, but prescribing the open test. In the following year the subject of testing was investigated by a Select Committee of the House of Lords, and a great deal of evidence was taken, but no satisfactory conclusion was arrived at.

At this period the position of the petroleum-testing question in this country was by no means promising. It had been found that the existing legal directions for testing were not sufficiently precise; the results obtained differing greatly, according to the interpretation of the expression "small flame," as applied to the source of heat; and "very small flame," as applied to the test flame; the officials employed by the local authorities frequently condemned oil that had been passed by independent and unbiassed experts acting on behalf of the traders; and retailers had thus no means of protecting themselves from the risk of being fined for selling oil flashing below the legal standard. Accordingly, with the concurrence and approval of the Metropolitan Board of Works, and of the Petroleum Association, Sir Frederick Abel was requested by the Government to undertake the investigation of the subject of petroleum testing, with the object of devising a satisfactory test. The outcome of Sir Frederick Abel's long and painstaking experimental inquiry, in which Dr. Kellner rendered valuable assistance, was the adoption by Parliament, on the 11th August, 1879, of what is now so well known as the Abel test. The instrument and its use are thus described in the Schedule of the 1879 Petroleum Act:—

SPECIFICATION OF THE TEST APPARATUS.

The following is a description of the details of the apparatus:—The oil cup consists of a cylindrical vessel 2 in. diameter, $2\frac{2}{10}$ in. height (internal), with outward projecting rim $\frac{5}{10}$ in. wide, $\frac{3}{8}$ in. from the top, and $1\frac{7}{8}$ in. from the bottom of the cup. It is made of gun metal or brass (17 B.W.G.) tinned inside. A bracket, consisting of a short stout piece of wire bent upwards, and terminating in a point, is fixed to the inside of the cup to serve as a gauge. The distance of the point from the bottom of the cup is $1\frac{1}{2}$ in. The cup is provided with a close-fitting overlapping cover made of brass (22 B.W.G.), which carries the thermometer and test lamp. The latter is suspended from two supports from the side by means of trunnions upon which it may be made to oscillate; it is provided with a spout, the mouth of which is one-sixteenth of an inch in diameter. The socket which is to hold the thermometer is fixed at such an angle, and its length is so adjusted that the bulb of the thermometer when inserted to full depth shall be $1\frac{1}{2}$ in. below the centre of the lid.

The cover is provided with three square holes, one in the centre, $\frac{5}{10}$ in. by $\frac{4}{10}$ in., and two smaller ones, $\frac{3}{10}$ in. by $\frac{2}{10}$ in., close to the sides, and opposite each other. These three holes may be closed and uncovered by means of a slide moving in grooves, and having perforations corresponding to those on the lid.

In moving the slide so as to uncover the holes, the oscillating lamp is caught by a pin fixed in the slide, and tilted in such a way as to bring the end of the spout just below the surface of the lid. Upon the slide being pushed back so as to cover the holes, the lamp returns to its original position.

Upon the cover, in front of and in line with the mouth of the lamp, is fixed a white bead, the dimensions of which represent the size of the test flame to be used.

The bath or heated vessel consists of two flat-bottomed copper cylinders (24 B.W.G.), an inner one of 3 in. diameter and $2\frac{1}{2}$ in. height, and an outer one of $5\frac{1}{2}$ in. diameter and $5\frac{3}{4}$ in. height; they are soldered to a circular copper plate (20 B.W.G.) perforated in the centre, which forms the top of the bath, in such a manner as to enclose the space between the two cylinders, but leaving access to the inner cylinder. The top of the bath projects both outwards and inwards about $\frac{3}{8}$ in.: that is, its diameter is about $\frac{6}{8}$ in. greater than that of the body of the bath, while the diameter of the circular opening in the centre is about the same amount less than that of the inner copper cylinder. To the inner projection of the top is fastened, by six small screws, a flat ring of ebonite, the screws being sunk below the surface of the ebonite, to avoid metallic contact between the bath and the oil cup. The exact distance between the sides and bottom of the bath and of the oil cup is one half of an inch. A split socket similar to that on the cover of the oil cup, but set at a right angle, allows a thermometer to be inserted into the space between the two cylinders. The bath is further provided with a funnel, an overflow pipe, and two loop handles.

The bath rests upon a cast-iron tripod stand, to the ring of which is attached a copper cylinder or jacket (24 B.W.G.) flanged at the top, and of such dimensions that the bath, while firmly resting on the iron ring, just touches with its projecting top the inward turned flange. The diameter of this outer jacket is $6\frac{1}{2}$ in. One of the three legs of the stand serves as a support for the spirit lamp attached to it by means of a small swing bracket. The distance of the wick holder from the bottom of the bath is 1 in.

Two thermometers are provided with the apparatus, the one for ascertaining the temperature of the bath, the other for determining the flashing point. The thermometer for ascertaining the temperature of the water has a long bulb and a space at the top. Its range is from about 90° to 190° Fahrenheit. The scale (in degrees of Fahrenheit) is marked on an ivory back fastened to the tube in the usual way. It is fitted with a metal collar fitting the socket, and the part of the tube below the scale should have a length of about $3\frac{1}{2}$ in. measured from the lower end of the scale to the bulb. The thermometer for ascertaining the temperature of the oil is fitted with collar and ivory scale in a similar manner to the one described. It has a round bulb, a space at the top, and ranges from about 55° Fahr. to 150° Fahr.; it measures from end of ivory back to bulb $2\frac{1}{4}$ in.

NOTE.—A model apparatus is deposited at the Weights and Measures Department of the Board of Trade.

DIRECTIONS FOR APPLYING THE FLASHING TEST.

1. The test apparatus is to be placed for use in a position where it is not exposed to currents of air or draughts.

2. The heating vessel or water bath is filled by pouring water into the funnel until it begins to flow out at the spout of the vessel. The temperature of the water at the commencement of the test is to be 130° Fahrenheit, and this is attained in the first instance either by mixing hot and cold water in the bath, or in a vessel from which the bath is filled, until the thermometer which is provided for testing the temperature of the water gives the proper indication; or by heating the water with the spirit lamp (which is attached to the stand of the apparatus) until the required temperature is indicated.

If the water has been heated too highly, it is easily reduced to 130° by pouring in cold water little by little (to replace a portion of the warm water) until the thermometer gives the proper reading.

When a test has been completed, this water bath is again raised to 130° by placing the lamp underneath, and the result is readily obtained while the petroleum cup is being emptied, cooled, and refilled with a fresh sample to be tested. The lamp is then turned on its swivel from under the apparatus, and the next test is proceeded with.

3. The test lamp is prepared for use by fitting it with a piece of flat plaited candle wick, and filling it with colza or rape oil up to the lower edge of the opening of the spout or wick tube. The lamp is trimmed, so that when lighted it gives a flame of about 0·15 of an inch diameter, and this size of flame, which is represented by the projecting white bead on the cover of the oil cup, is readily maintained by simple manipulation from time to time with a small wire trimmer.

When gas is available, it may be conveniently used in place of the little oil lamp, and for this purpose a test-flame arrangement for use with gas may be substituted for the lamp.

4. The bath having been raised to the proper temperature, the oil to be tested is introduced into the petroleum cup, being poured in slowly until the level of the liquid just reaches the point of the gauge which is fixed in the cup. In warm weather the temperature of the room in which the samples to be tested have been kept should be observed in the first instance, and if it exceeds 65°, the samples to be tested should be cooled down (to about 60°) by immersing the bottles containing them in cold water, or by any other convenient method. The lid of the cup, with the slide closed, is then put on, and the cup is placed into the bath or heating vessel. The thermometer in the lid of the cup has been adjusted so as to have its bulb just immersed in the liquid, and its position is not under any circumstances to be altered. When the cup has been placed in the proper position, the scale of the thermometer faces the operator.

5. The test lamp is then placed in position upon the lid of the cup, the lead line or pendulum,* which has been fixed in a convenient position in front of the operator, is set in motion, and the rise of the thermometer in the petroleum cup is watched. When the temperature has reached about 66°, the operation of testing is to be commenced, the test-flame being applied once for every rise of one degree, in the following manner:—

The slide is slowly drawn open while the pendulum performs three oscillations, and is closed during the fourth oscillation.

NOTE.—If it is desired to employ the test apparatus to determine the flashing points of oils of very low volatility, the mode of proceeding is to be modified as follows:—The air-chamber which surrounds the cup is filled with cold water to a depth of $1\frac{1}{2}$ inch, and the heating vessel or water bath is filled as usual, but also with cold water. The lamp is then placed under the apparatus and kept there during the entire operation. If a very heavy oil is being dealt with, the operation may be commenced with water previously heated to 120°, instead of with cold water.

By no means the easiest part of Sir Frederick Abel's task was the determination of the equivalent test standard, since the Abel instrument furnishes no exception to the rule that the flashing point of a given sample of mineral oil is far lower in a closed than in an open vessel, and it was therefore necessary to deal with the conflicting views already referred to, as to the proper mode of conducting the test with the open cup instrument, in order to determine the equivalent standard. I had the honour of being associated with Sir Frederick in the conduct of this portion of the inquiry, but before the test standard was fixed, Mr. T. W. Keates, as representing the Metropolitan Board of Works, and Mr. John Calderwood, on behalf of the Scottish Mineral Oil Association, were also consulted. Eventually, as the outcome of the joint experiments, it was ascertained that the difference between the results afforded by the open-cup instrument and the Abel tester ranged from 25° to 29° Fahr. Taking the mean difference of 27°, the new standard was accordingly fixed at 73° Fahr.

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* The pendulum should be 24 inches in length from the point of suspension to the centre of gravity of the weight.

The Abel testing apparatus, in the form in which it was adopted by the Legislature, was by far the most perfect instrument that had been devised for the purpose, and all those who are commercially or officially interested in petroleum, owe Sir Frederick Abel a debt of gratitude for devising a comparatively precise method of determining flashing point.

In 1880, the German Government ordered an inquiry into the subject of petroleum testing similar to that which Sir F. Abel had conducted. The investigation was carried out with characteristic attention to detail, a large number of different forms of apparatus were experimented with, and, in the end, the Abel tester was declared to be the best. It was, however, considered desirable to render the action of the apparatus as nearly as possible automatic, and accordingly clockwork mechanism for moving the test-slide was added. The German modification of the Abel apparatus is before you, and you will observe that, with the exception referred to, the instrument is practically the same as the English model. The clockwork movement, which is wound up prior to each application of the test-flame, and released by pressing a trigger, is, in my opinion, a decided improvement. The rate of moving of the test-slide is, it is true, defined in the English Act, but it has been found that the element of personal error is occasionally of more importance than might have been expected. The German test standard is 21° C. at a barometric pressure of 760 mm. In the English Abel instrument, alternative arrangements for igniting the vapour by means of an oil lamp and gas jet are provided; but the German apparatus is supplied with the oil lamp only, as it was found that the two arrangements did not furnish in all cases precisely concordant results.

The Abel tester had not been very long in use in this country before it was found that the results afforded by it were materially affected by atmospheric pressure. I believe the effect of variations in pressure, which might safely have been predicted if it had been thought of, was first accidentally observed in Germany. At any rate the first series of experiments, having for their object to determine the extent of the effect, was made in that country. The results were obtained by using the apparatus in an air-tight chamber in the Jewish Hospital in Berlin. This chamber had been constructed for the treatment of cases of pulmonary affections, and it was so arranged that either a reduced or an increased atmospheric pressure could be maintained within it. The experiments thus made showed that the difference in flashing point amounted to about 0·30° C. for 10 mm. in the height of the barometric column, though some of the earlier results showed, I believe, even greater differences. Subsequently, in association with Sir Frederick Abel, I made some similar experiments at different altitudes in Switzerland. The number of samples thus examined was too small to justify the basing of a table of corrections on the results afforded, and in fact, the experiments were undertaken, not so much with this object as to obtain further tangible evidence of the influence of barometric changes upon the flashing point. The differences noted in these experiments were somewhat greater than those which had been observed in the Berlin pressure chamber, being at the rate of about 2° F. for 1 in. of barometric pressure. Experiments afterwards made by Dr. Lyon, in India, afforded results confirmatory of those which had been obtained in Germany.

Some experiments made jointly by Dr. Lyon, Chemical Analyser to the Bombay Government, and by myself, in Bombay and in London, respectively, seem to show that the results afforded by the open cup testing instrument are still more affected by changes in barometric pressure. These experiments were made with an apparatus devised by Dr. Lyon, and constructed by Mr. Casella, wherein the vapour was ignited by the flame of a small gas jet sliding on a fixed support at a given distance above the surface of the oil.

About five years ago, the Abel test was adopted by the Indian Government, and somewhat unwisely, as it turned out, the directions for the use of the test were copied *verbatim* from the English Act. These directions had been framed by Sir Frederick Abel with a view to the use of the test in a temperate climate, and although provision had been made for the cooling of the sample when the temperature of the air exceeded 65° Fahr., this was not found to be the only precaution necessary when the test was employed in a tropical country. The discovery of the need for the adoption of a modified system of procedure in the use of the test was made somewhat unpleasantly in connection with the condemnation by the authorities in Calcutta of several cargoes of petroleum oil. I proceeded to India when this occurred, and as the result of experiments made in that country, and a further series of tests conducted by Sir Frederick Abel and myself, with the assistance of Dr. Kellner, in an apartment heated to a tropical temperature at Woolwich Arsenal, it was found that a much lower flashing point than that given in a temperate climate was liable to be obtained when the Abel test was applied in tropical countries in the manner prescribed by the English Act. Further experiments made independently and jointly by Dr. Warden, analyst to the Bengal Government, Professor Pedler, Dr. Lyon, Sir Frederick Abel, Dr. Kellner, and myself, showed that the depression of the flashing point was largely due to vapour which became disengaged in the act of filling the oil cup and collected on the surface of the oil in the cup. Prolonged cooling of the oil appeared to reduce the liability to this disengagement of vapour, but the only practically available method of eliminating this source of discrepancies was found to be the adoption of some method of getting rid of the vapour before commencing the operation of testing, or before the flashing point of the oil was reached. Various methods of effecting this object were tried. The vapour was easily removed by gently blowing over the surface of the oil in the cup or by the use of an aspirator attached to the cover, or by leaving the test-slide withdrawn for some time, but it was ultimately decided to recommend the commencement of the test many degrees below the flashing point. The effect of this modification is to withdraw the separated vapour in successive quantities too small to produce a flash, and the apparatus is thus caused to give results in a tropical country which agree very closely with those which it furnishes in a temperate climate. Obviously, a portion of the volatile constituents of the oil become dissipated in this mode of conducting the test, but since petroleum oil cannot be exposed to the air in the tropics without this loss occurring, the defect is not of practical importance. Further details in connection with the subject of petroleum testing will be found in Sir Frederick Abel's elaborate report to the Secretary of State, dated 12th August, 1876, in an interesting lecture delivered by Sir Frederick Abel to the Society of Chemical Industry, in 1882, and (as regards the influence of a tropical climate) in a joint communication by Sir F. Abel and myself published in the *Chemical News*, on the 2nd May, 1884.

There are yet some other systems of testing to which I must now direct your attention. In 1882, Braun, of Berlin, patented a magnetic pendulum arrangement for applying the test flame in the Abel apparatus. In 1881, Engler and Haas made a number of experiments with the Abel apparatus and other testing instruments, and expressed the opinion that the addition of an arrangement for agitating the oil was desirable.* They based their opinion apparently upon the facts that in all the closed testers there is during the operation a layer of vapour of gradually increasing thickness formed upon the surface of the oil; that consequently no two apparatus will give concordant results unless the size and shape of the oil cup, the height to which the cup is filled, the rate of heating, the distance from the surface of the oil at which the test-flame is applied, the size of the test-flame, the dimensions of the orifices in the cover, and other conditions are the same; and, further, that since the temperature of the oil is not uniform throughout, the position of the thermometer bulb must be precisely defined. I have no doubt that with the use of a mechanical arrangement for agitating the oil and the air in the cup, results less dependent upon the conditions enumerated are obtained, but since all the standard measurements are most carefully adhered to, and the position of the thermometer bulb is prescribed, the objections to the apparatus are not in my opinion valid, and it is quite possible that the use of a stirrer might in practice be found to introduce some element of error. I have had, in the discharge of my duties, a very large experience in the use of the Abel tester in its English and German forms, and I should be sorry to see the apparatus further modified, since I know that it is easy to obtain, with ordinary care, results with it not varying more than 1° Fahr. Liebermann has recommended the blowing of air through the oil during the process of testing, and Beilstein devised an apparatus, based upon this principle, which consisted of a glass cylinder to hold the oil, with a tube passing to the bottom, and furnished with a rose jet. At intervals, air was forced through the jet at a rate sufficient to raise a foam of a prescribed depth upon the surface of the oil, and the test-flame was at the same time applied. Stoddard subsequently suggested a modification of Beilstein's apparatus, in which the rose jet was replaced by a glass tube drawn out to a small orifice.

Bernstein's tester is constructed on the principle of gradually heating the oil until a temperature is reached at which, on raising the level of the oil, vapour is forced out of the testing chamber, and ignited at a stationary flame. Ehrenberg has proposed to use a syringe to expel the vapour from the closed testing cup, and thus bring it into contact with a flame.

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* Victor Meyer is stated to have been the first to propose the addition of a stirrer.

Of apparatus in which the flashing point of the oil is only determined inferentially by noting the vapour tension, the best known is the Salleron-Urban instrument, which is used to some extent in France.

In a Table published in 1866, Salleron and Urbain give the following figures of specific gravity and vapour tension of petroleum products at 15° C.:—

Density at 15° C.	Tension in mm. of water.
·812	0
·797	5
·788	15
·772	40
·762	85
·756	125
·735	410
·695	930
·680	1,185
·650	2,110

I am indebted to Professor Sell, of Berlin, and to Mr. Berthold Pensky, of Berlin, for specimens of certain of the instruments described.

I have now referred to the principal though not the whole of the arrangements for testing the flashing point, or fire test, of petroleum, and we must, in the next place, give some further consideration to the subject of petroleum legislation.

In the United States we find considerable diversity of opinion among authorities as to the method of testing and the standard to be selected, and almost all the States have adopted different legislation in these principles. When petroleum was first introduced in that country as an illuminant, it was often used carelessly and improperly, and many accidents occurred. An exaggerated estimate of the risk involved in the use of the oil was thus formed, and laws were then passed which, in some instances, were so stringent that they could not be enforced. Moreover, recent experiments by Sir F. Abel and myself, in this country, and by the officials of the Normal Eichungs Kommission in Berlin, have shown that an oil of high flashing point may, in some cases, be actually less safe than one of lower flashing point. The experience of several years has demonstrated that the proper use of an oil of comparatively low flashing point (say 70° Abel test) is free from danger, and there is reason to believe that authorities in the United States are beginning to realise that their petroleum laws would be rendered far more effective for the protection of the public by the substitution of more moderate test requirements.

Petroleum legislation in this country has hitherto been confined to those products which give off an inflammable vapour below the legal limit. Exception has, however, been taken to this by the Metropolitan Board of Works, who contend that between oil which flashes at 72°, and oil which flashes at 73°, there can be no practical difference in regard to inflammability. In advancing this view, however, it appears to have been forgotten that since the liquids which flash below the standard can only be stored and sold in comparatively small quantities, and under troublesome restrictions, the practical effect of such legislation is that elaborate precautions are adopted to insure that all the burning oil imported has a flashing point not below the limit; the only liquid dealt with in accordance with the provisions of the Acts being petroleum spirit (benzoline and gasoline). I am of opinion that the placing of the sale of burning oil (flashing not below 73° F.) under legislative restrictions would be to obliterate, to some extent, the distinction which the present laws have created. Moreover, I am not aware there are any grounds for supposing that petroleum oil constitutes a dangerous article in the ordinary stock of an oilman. On the contrary, I have collected in the discharge of my official duties a good deal of evidence in support of the opposite view. Thus, to take one instance only, on visiting the scene of one of the most recent fires at an oilman's shop, in company with an officer of the Metropolitan Board of Works, I found that almost the only portion of the contents of the shop which had escaped destruction were three barrels of petroleum oil, constituting, according to the evidence given, the whole stock of this material on the premises at the time of the fire. These barrels were a good deal charred, but still held a considerable quantity of oil. Petroleum is, in fact, a far less dangerous liquid than is commonly supposed, as was pointed out some years ago, and again last year, by Sir Frederick Abel in lectures at the Royal Institution. Statistics show that the destruction of petroleum-laden ships by fire is very rare, and at least one case is on record where a vessel carrying petroleum having been set on fire by lightning, the fire was extinguished and the cargo brought safely into port. I saw many barrels discharged from the vessel in question which bore evidence of the heat to which they had been subjected, being in some cases so much charred that a penknife blade could be driven through the staves, and yet these barrels still held the oil intact.

In consequence, partly, of the expressed views of the Metropolitan Board of Works, to which I have alluded, a Petroleum Bill was introduced by the Government in 1883 to place the storage and sale of petroleum oil under legal restrictions; but the measure was practically condemned by a Select Committee of the House of Lords, and was withdrawn. Subsequently I accompanied Colonel Majendie, her Majesty's Chief Inspector of Explosives, on a visit to Germany, Austria, France, Belgium, and Holland, with the object of assisting him in the collection of information in regard to petroleum legislation in those countries. In a memorandum issued in 1884, Colonel Majendie set forth the result of his observations and inquiries, the information he collected being supplemented by particulars obtained from consular reports and other sources. The result of the inquiry showed that in all the principal countries of Europe the traffic in mineral oil was to a greater or less extent under the control of State or municipal authorities, but in many respects the restrictions were far less stringent than those proposed by the Bill of 1883. There is no doubt much to be said in favour of the contention that the storage of mineral oils in large quantities should take place only under specified conditions, so that in the event of a fire occurring, outflow of burning oil from the premises could not occur, but it is difficult to see how legislation to give effect to this view could fairly and justifiably be advocated unless it took the shape of a comprehensive measure embracing other inflammable liquids.

We have now dealt with that which is the most important of all the tests applied to petroleum products, since, as we have seen, legislative enactments framed in the interest of public safety are based upon it. There are, however, many commercial tests to which I must now direct your attention for a brief space of time.

The colour of petroleum oil is determined in this country, in America (as regards oil for export), in Germany, and in Russia (in the case of oil for export), by the use of a chromometer patented by Mr. R. P. Wilson, a member of the committee of the Petroleum Association of London, in 1870. This instrument is fitted with two parallel tubes furnished with glass caps, and at the lower end of the tubes is a small mirror, by means of which light can be reflected upwards through the tubes into an eye-piece. One of the tubes is completely filled with the oil to be tested, and beneath the other tube, which remains empty, is placed a disc of stained glass of standard colour. On adjusting the mirror and looking into the eye-piece, the circular field is seen to be divided down the centre, each half being coloured to an extent corresponding with the tint of the oil and of the glass standard respectively. An accurate comparison of the two colours can thus be made. The glass discs, which for the English trade are of five shades of colour, termed—good merchantable, standard white, prime white, superfine white, and water white, are issued by the Petroleum Association of London, and the instruments are all precisely similar in construction; thus the testing of colour, wherever these chromometers are used, is placed upon a uniform basis.

A German modification of the instrument (devised by Stammer), now before you, is provided with an arrangement for shortening the column of oil, and thus obtaining an exact match with the standard. The extent of shortening being indicated on the scale, the colour of the oil can be recorded in terms of the standard with considerable precision.

Both fire test and flashing point of lubricating oils are determined by testing the oil in an open cup. One form of apparatus employed is on the table. There is no generally, or at any rate universally, accepted method of applying these tests, and important discrepancies between the results of different operators frequently occur. These discrepancies chiefly arise from variations in the rate of heating the oil. Pensky, of Berlin, constructs a closed cup apparatus for testing lubricating oils, which, as you see, in principle resembles the Abel instrument. As, however, the trade are accustomed to judge of the volatility of lubricating oils by their open vessel flashing points or their fire tests, the closed cup cannot usually be employed. The method of heating the oil adopted by Pensky, which consists in placing the oil cup in an air chamber in a cast-iron vessel which can be strongly heated, is a convenient one, and I find that on using the Pensky apparatus without the oil-cup cover, and adjusting the Bunsen burner flame, which is used as a source of heat, so that the temperature of the oil is raised at the rate of about 10° per minute, I obtain concordant flashing points and fire tests, which agree with those furnished by the method of testing usually adopted in America. A gas flame not more than a quarter of an inch in diameter, produced by the use of a small jet, is a good test flame to use.

The so-called "cold test" of lubricating oils is the temperature at which the oils either become cloudy or cease to flow through crystallisation of paraffin. The test is usually applied by slowly cooling a sample of the oil in a tube about 1⅜ in. in diameter, and noting the temperature at which on inclining the tube the oil no longer flows, or that at which separation of paraffin commences.

The viscosity of mineral lubricating oils is a feature which is intimately associated with their lubricating properties. I have recently dealt somewhat fully with this subject in a paper read at a meeting of the Society of Chemical Industry,* and I will therefore only say that the apparatus commonly employed in testing consists of an arrangement for noting the length of time occupied by a given quantity of the oil in flowing through a small orifice of given dimensions and form at a given temperature. The viscosimeter employed in my laboratory is on the table. This instrument, properly standardised, can be obtained of Messrs. James How and Co., 73, Farringdon-street.

Paraffin scale, or partially refined paraffin wax, usually contains oil, and sometimes water. The per-centage of oil is determined by subjecting a weighed quantity of the material to a given pressure at a given temperature for a specified time, and noting the loss in weight. I published in the *Journal of the Society of Chemical Industry*, in August, 1884, the particulars of the method of testing which I am accustomed to adopt, and gave comparative results obtained under various pressures, with various lengths of exposure to the pressure at various temperatures, and with various quantities of material. My experiments showed that differences of temperature affect the results far more than differences in pressure and in the quantity of material do. This is not surprising when we consider that there is no actual line of demarcation between the solid and liquid hydrocarbons obtained from petroleum. It is, however, important that the same pressure should always be employed, and accordingly, some years ago, I had a press constructed which indicates the amount of pressure by the extent of deflection (magnified by levers) of the steel cross-head. The test is made at 60° F., the temperature of the press plates being indicated by thermometers placed in mercury cups; the quantity of material employed is 500 grains, the pressure is 9 tons over the whole surface of the circular press cake, 5⅝ in. in diameter, and this pressure is maintained for five minutes, the oil expressed being absorbed by blotting paper. I have recently had a press constructed in the United States for use in testing, which is furnished with a long, heavily-weighted lever in place of the spring cross-head. With this press I find that I obtain similarly concordant results, and the objection to a spring, that it may become weaker through use, does not, of course, attach to the weighted lever method of indicating pressure. Some time after I commenced the regular use of the spring press referred to, Mr. McCutchon, of Young's Paraffin Oil Company, constructed a testing press in which coiled steel springs were substituted for the elastic cross-head, and this press has been adopted by the Scottish Mineral Oil Association. Mr. William Walls, of Glasgow, recommends the use of a hydraulic press, and Messrs. Clarkson and Beckitt, of Glasgow, a few months ago, sent me a well-made press of this nature, with which I have conducted a number of experiments. A hydraulic press is portable, occupies less space than a screw press, and admits of a specific pressure being applied with ease and certainty. I found that the press acted promptly even after being out of use for many days. I do not, however, recommend the use, with a hydraulic press, of a greater pressure than I am accustomed to apply with the screw-press. Under a great pressure the scale is liable in some cases to be squeezed out of the cloth, and I have not found that the quantity of oil expressed is materially increased. Thus, in some comparative experiments conducted at various pressures, all the other conditions being alike, I obtained the following results:—

PRESSURE ON WHOLE CAKE.

Sample.	9 tons oil.	13·3 tons oil.	20 tons oil.
A ..	2·9 per cent. ..	3·1 per cent. ..	not taken.
B ..	14·8 ,, ..	14·4* ,, ..	not taken.
C ..	2·5 ,, ..	not taken. ..	2·9 per cent.
D ..	5·5 ,, ..	not taken. ..	6·1 ,,

* Temperature slightly lower.

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* Published in the *Journal of the Society of Chemical Industry*, on the 29th March last.

Water in paraffin scale is usually determined by heating a weighed sample to a temperature somewhat above the boiling point of water, and maintaining it at that temperature until it ceases to lose weight.

The so-called "melting point" of paraffin is, in the case of the recognised American and English methods of making the test, the temperature at which the sample, after having been melted, and while in the process of cooling, begins to solidify. The American test is conducted by melting sufficient of the sample to three parts fill a hemispherical dish $3\frac{3}{4}$ in. in diameter. A thermometer with a round bulb is suspended in the fluid so that the bulb is only three-fourths immersed, and the material being allowed to cool slowly, the temperature is noted at which the first indication of filming extending from the sides of the vessel to the thermometer bulb occur. The English test is made by melting the sample in a test tube, about three-quarters of an inch in diameter, and stirring it with a thermometer as it cools, until a temperature is reached at which the crystallisation of the material produces enough heat to arrest the cooling, and the mercury remains stationary for a short time. The results afforded by this test are usually from $2\frac{1}{2}$° to 3° F. lower than those furnished by the American test. The melting point is also sometimes determined by observing the temperature at which a minute quantity of the sample, previously fused into a capillary tube and allowed to set, becomes transparent when the tube is slowly warmed in a beaker of water.

Miscellaneous.

COLONIAL AND INDIAN EXHIBITION.

THE INDIAN SCREENS.

Part II.

Bengal.

The screens of this court illustrate, chiefly by means of *papier mâché* castings, the styles of architectural ornament characteristic of the best Hindu and Mohammedan buildings in Bengal proper. The northern is Hindu, the southern Mohammedan.

The Hindu Screen is adapted from the temple of Krishna at Kantanagar, near Dinajpur, built between 1704 and 1722 A.D. This temple forms an example of the brick architecture of Lower Bengal, and one of its chief constructive peculiarities, the bent cornice (supposed by the late Mr. Fergusson to have been copied from the common bamboo hut of the country) has been reproduced in the screen.

The Mohammedan Screen was designed by the late Mr. Jules Schaumberg, artist to the Geological Survey of India, on the lines of the architecture of the ancient city of Gaur and its suburb Panduah. The general idea of the screen was derived from the Qadam Rasul Mosque, built by Nusrah Shah in 1530; the flat pilasters bulging outwards at the bottom are adapted from the tomb of Sultan Ghyasuddin (1211—1227), known as the Eklahi Mosque, at Pandua, while the detailed ornamentation consists of casts taken from the remains of these and other buildings preserved in the India Museum, Calcutta. The painted design at the east end of the screen is a composition from carved stones and tiles in the museum, and is intended to represent the enamelled tiles with which the Gaur and Pandua buildings were overlaid.

Nepal.

The front face of this elaborate screen, which is double, consists of a large central plaque, and two smaller side plaques of carved birch wood, divided and bordered by panels of carved satisal wood.

The central plaque is a copy, half the actual scale, of a window (about two or three hundred years old) above the entrance of an ancient Newar Vihar, or monastery in the town Patan. The side plaques are copies on a reduced scale of windows frequently seen in old Newar buildings—either monasteries, temples, darbars, or private dwellings. An example of this portion of the screen was given with the first part of this article. The inner face of the screen is of carved birch-wood, the patterns shown being reproductions of types of ancient Newar decorative carving. The double row of pillars and arches supporting the screen are copied from the enclosure of the temple at Tripureswar, on the banks of the river Baghmati near Katmandu. The carving of the front face of the central arch is supposed to represent a cloudy sky, the winged figures being angels, or the substitute for them in Newar mythology, and the dragons are symbolic of lightning.

A recognised authority on Indian art has said that "the ornamental details of this screen are rendered with the utmost dexterity, and are deeply interesting as showing at once the near affinity of Nepaulese with Chinese art, and its uninterrupted descent from the ancient Buddhistic art of India, as exemplified by its remains at Sauchi, Amravati, and elsewhere.

North-West Provinces.

Agra.—The screen in this court may be divided into three series. The marble pillars were found to be too large to be placed in the position they were intended to occupy across the Court, and have therefore been placed outside between the Private Exhibition Court and the Indian Palace. They are inlaid with precious stones, and have been taken from a large number of pillars of similar design now lying in the

Fort at Agra; they constitute a gift from the Government of the United Provinces to the National collection at South Kensington. The inlaid work on the pillars is similar to much of that on the world-famed Taj, and it is supposed that they were constructed with a view to the extension of the buildings known as the Diwan-i-khas.

One of the screens placed in the court consists entirely of stone-carving executed at Muttra and Agra for the Royal Commission. The trellised screens are faithful copies of similar screens in the Taj and at Fatehpur Sikri, respectively, while the open arches are in like manner copies of work to be seen in the Agra Fort and Fatehpur Sikri.

The other is entirely of wood-work. The ends of the court were furnished by workmen from the districts of Bulandshahr and Mainpuri, while the greater portion of the frontage was dug out of ancient houses in Lucknow City.

THE PUNJAB.

This screen consists of six sections or arcades. The northern of the longer ones, wrought in shisham, the cabinet wood of the Punjab, was made at Udoki, a village in the Amritsar district, by a large family of Sikh carpenters. The pillars are slightly varied in detail, and the proportion of the parts is according to the received canons of to-day, as derived from Mogul architecture. The horizontal panels are in framed geometric lattices (not perforated), locally known as Pinjra, literally "cage-work," strongly resembling the lattice work seen in Arabic architecture. One set of the horizontal panels is in shisham wood, inlaid with ivory.

The southern length opposite, in deodar or Himalayan cedar (*Cedrus deodara*), is the work of various Sikhs in Lahore. Deodar wood is full of resin, and, consequently, is not attacked by insects, and is extremely durable.

The end arcades—two in shisham and two in deodar—are designed in a different style, known among Punjab workmen as Akbari.

KASHMIR.

"The screen for the Kashmir Court," writes Sir Oliver St. John, Resident in Kashmir, "is copied from the verandah of an old wooden mosque near Chakoti, on the Kashmir Murree road, to which the attention of travellers is invited in Ince's handbook. The date of its erection was not, as far as I could find, anywhere marked on the building, but tradition and the character of the carving seem to point to the earlier part of the last century. The pillars, brackets, and architrave beam of the screen are almost an exact copy of the original both in design and proportion. . . . The material is deodar wood."

CENTRAL PROVINCES.

The screens are the handiwork of native carpenters at Nagpur, and are very fair specimens of the wood-carving which is very characteristic of the Central Provinces. Carving in wood, and to a less degree in stone, is perhaps the only art in which these provinces can hold their own against other provinces in India. Carved wood plays an important part in Nagpur architecture, and the Maratha palaces in the vicinity of the city are distinguished by their high verandahs of black teak often very elaborately decorated.

ASSAM.

This screen is composed almost entirely of bamboo and cane, but a kind of mat locally known as *sital patti* and some native silk cloths have been also used in its manufacture. The whole length of the screen is covered by a board, the under-surface of which is covered with the best *sital patti* matting. The workmanship is so fine that twenty-three strips of the *patti* go to one inch.

BURMA.

The screen is made of carved teak with *kalaga* (or cloth hanging) panels. The upper part resembles the carving placed round the eaves and gables of Burmese monasteries, palaces, and shrines. The small flame-like pinnacles perhaps point back to a former fire-worship era. The frame-work just below is an example of the ordinary wood-carving of the country, and the *kalagas* (or *appliqué* work) which are placed as panels, are part of the hangings used as screens, roofings, or backgrounds at open-air festivals or in-door feasts. The pillars are ornamented in red and gold, in a manner common in shrines and monasteries of the country.

MADRAS.

The screens are in a style of the Dravidian architecture of Southern India of the Vijaynagar period, *i.e.*, about the 15th or 16th century. Avoiding as far as possible the grotesque eccentricities of the style, it is attempted to show that South Indian carvers are capable of much good work. The columns are fluted and ribbed, and crossed at intervals with bands of elaborate ornament. The upper portion is cut in representation of a chatty, or earthen vessel, from which the capital springs in the shape of a lotus. The Hindu architects use an elaborate system of brackets in place of the arch construction of Saracenic and European builders. The long beam on which the entablature of the screen rests is divided into panels filled with various designs of foliage, birds, gryphons, and other monsters of Hindu mythology. That which might be called the frieze of the entablature is divided into panels by carved upright struts. The panels themselves are each divided into three niches, the design being adapted from the metal shrines in which the Hindus place the images of their gods. The variety of the patterns on the screen, and the treatment of animal forms, will give a good idea of the facility for ornamental design possessed by most Oriental handicraftsmen. The screen is constructed of Burma teak, by a Madras carpenter. The general design was prepared by the Superintendent of the Madras School of Arts, and executed under his direction by about twenty Madras carvers.

HYDERABAD.

The screen consists of a series of arches, giving excellent examples of the brass work a d lacquer work of the provinces, and of Bidri ware, *i.e.*, blackened pewter inlaid with gold, silver, or copper. The central portion of the screen, or, as it may well be termed, the central gateway, is a Tazzia, such as is commonly constructed during the Mohorran festival, to represent the Mausoleum of Hassain and Hussain.

MYSORE AND COORG.

The front elevation is divided into seven bays, five for Mysore and two for Coorg. The designs for the pillars and arches are copied from the Daria Daulat Bagh (the Garden Palace, built by Tippoo Sultan at Seringapatam, and long occupied by the Duke of Wellington, then Colonel Wellesley), reduced to half the original dimensions. The pillars and panels are carved by local carpenters of different sorts of Mysore timber. The plain panels above the arches of the front elevation and at the sides and top of the three partition screens are filled in with coloured photographs of Mysore scenery and native mythological paintings. Across the end of the gallery is placed a screen of Hyderabad design, in lacquer work. Over the central arch is the motto, in Arabic and English, "With God alone is victory."

The number of visitors to the Exhibition for the week ending July 10th, was 167,489; making a total since the opening of 1,650,448.

Obituary.

EDWARD CARLETON TUFNELL.—Mr. Edward Carleton Tufnell, who was a member of the Society since 1853, died on the 3rd inst., in the 81st year of his age. Mr. Tufnell was for nearly forty years one of her Majesty's Inspectors of Poor Law and Industrial Schools. The great results of the district schools of the metropolis, notably of Hanwell and Anerley, are largely due to him; indeed, he was one of the earlier supporters of the half-time system of industrial education, the leading feature of those schools. Mr. Tufnell travelled extensively on the Continent in 1838-6 with the late Sir James Kay-Shuttleworth, to examine into the state of elementary education; and on their return they became the founders of Battersea College, the first training institution of its kind in England, which was at first largely supported by Mr. Tufnell's private liberality. The extensive development of the pupil teacher scheme in national schools has been in great measure owing to him, and he was instrumental, in conjunction with Mr. Edwin Chadwick and Sir Henry Cole, in introducing drill into elementary schools. On his retirement from the public service in 1875, he was presented with a service of plate by head masters of elementary schools and others, in recognition of his services. Mr. Chadwick presided at the meeting at which the presentation was made, and in an address which he delivered, gave a very full account of Mr. Tufnell's labours. Mr. Tufnell, in his reply, described the spirit by which he had been actuated in his efforts to promote the advance of education. A report of both speeches wlll be found in the *Journal* for May 21, 1875. Mr. Tufnell was on the Society's Council from 1869 to 1877, and always took a prominent part in the educational work of the Society.

General Notes.

INDUSTRIAL EXHIBITION AT STOCKHOLM.—An Exhibition of motors and machine tools, tools and models for small industries, was opened at Stockholm, on the 12th July, and will be kept open until the 12th September; it includes the following groups:—1. Motors for small industries; 2. Machine tools for wood, stone and metal; 3. Machines for textile fabrics, leather, skins, paper, &c., with auxiliary machines and appliances; 4. Machines and apparatus of small size for the production and application of electricity. Only small machines are admitted, objects requiring more than 21½ square feet of ground space only being admitted exceptionally. No charge is made for space; and applications are to be made to the Utstallnings Komiterade, Stockholm, Handtverks föreningenshus, Sweden. An agricultural show and congress is also being held from 12th to 18th July.

MEETINGS FOR THE ENSUING WEEK.

The following are Conferences for the week ending July 24th, at the Colonial and Indian Exhibition:—

MONDAY, JULY 19...Mr. R. W. Murray, "Table Bay as a Harbour of Refuge." 4 p.m.

TUESDAY, JULY 20...Mr. D. Morris, "Tropical Fruits." (Illustrated with specimens and diagrams.) 4 p.m.

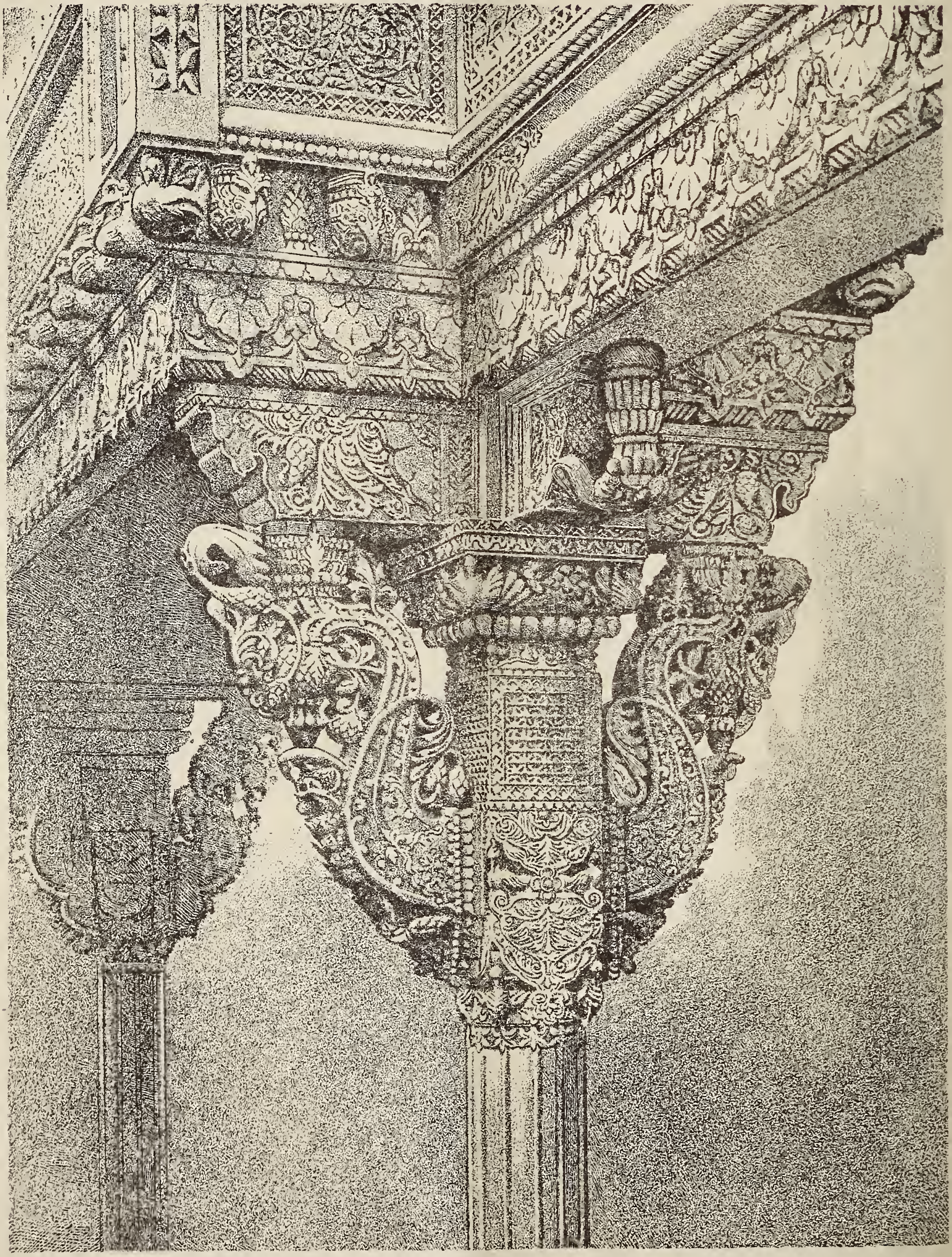
WEDNESDAY, JULY 21...Mr. J. Fforde, "South African Railways, Harbours, and other Public Works." 4 p.m. Mr. J. Peter, "Indian Tea." 8 p.m.

THURSDAY, JULY 22...Colonel Campbell, "Coffee Growing in Mysore and Southern India." 3½ p.m. Mr. F. W. Pennefather, "New Zealand as a Field for Tourists." (With Lime-light illustrations.) 8½ p.m.

FRIDAY, JULY 23...Mr. Alexander Begg, "Emigration to the Canadian North-West." (With Lime-light Illustrations.) 8½ p.m.

SATURDAY, JULY 24...Conference of East India Association. Mr. William Martin Wood, "The Indian Gold and Silver Plate Industries." 3 p.m.

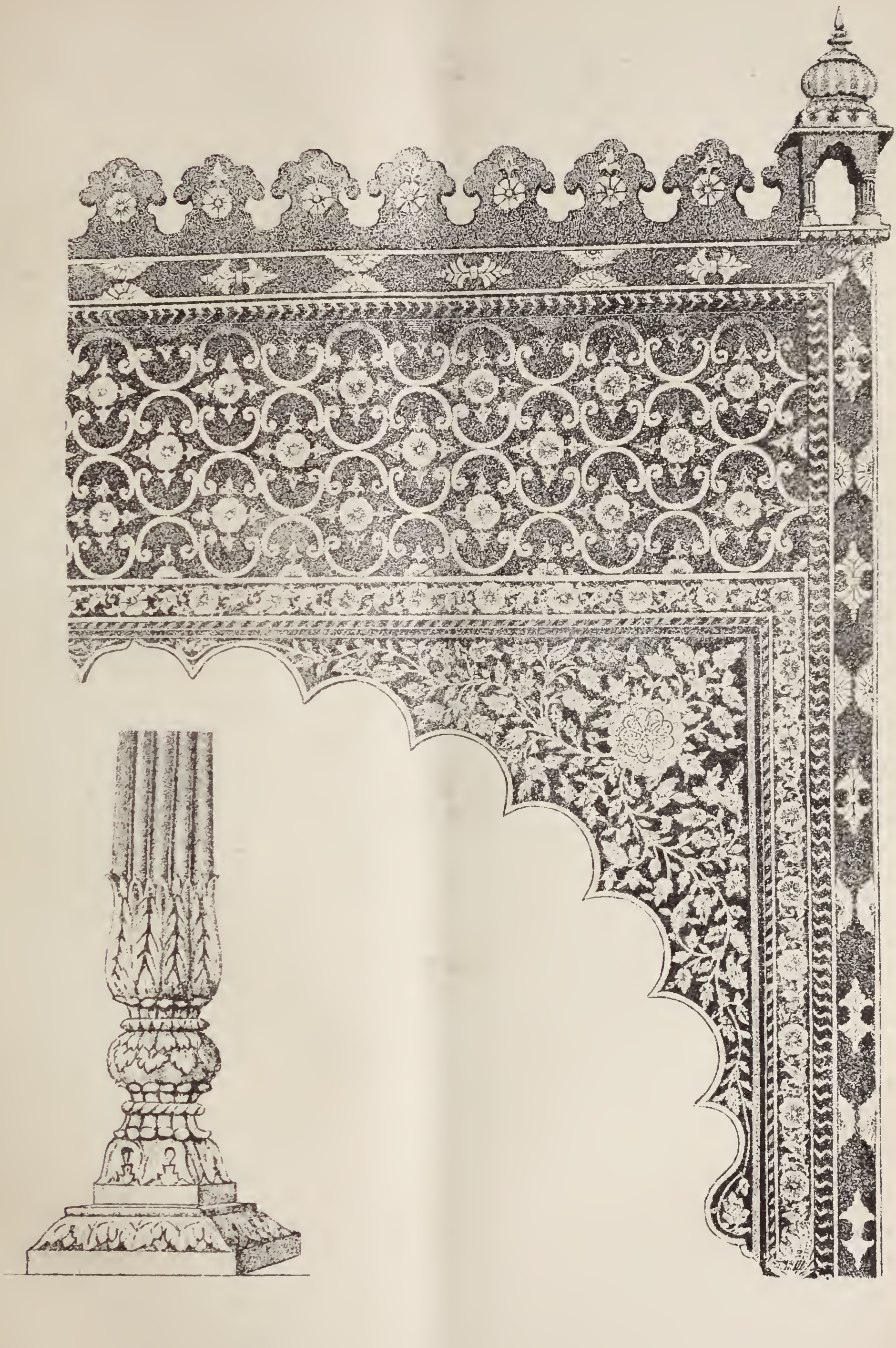
SUPPLEMENT TO SOCIETY OF ARTS JOURNAL, JULY 16th, 1886.



DETAIL OF DARODA SCREEN.

Photo-lith. W. Griggs.

SUPPLEMENT TO SOCIETY OF ARTS JOURNAL, JULY 16th, 1886.



DETAIL OF STONE PILLAR.
GWALIOR.

DETAIL OF KOTAH SCREEN.

Journal of the Society of Arts.

No. 1,757. Vol. XXXIV.

FRIDAY, JULY 23, 1886.

All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

NOTICES.

CONVERSAZIONE.

The Society's Conversazione was held, by permission of the Royal Commission for the Colonial and Indian Exhibition, at the Exhibition buildings, South Kensington, on Friday evening last, 16th July.

The reception was held in the Middle Court, (Indian Empire) by Sir Frederick Abel, C.B., D.C.L., F.R.S., and the following members of the Council:—Mr. William Anderson, Sir Francis Dillon Bell, K.C.M.G., Sir Frederick Bramwell, D.C.L., F.R.S., Mr. Brudenell Carter, F R.C.S., Mr. Edwin Chadwick, C.B., Lord Alfred S. Churchill, Mr. B. Francis Cobb, Mr. Vicat Cole, R.A., Sir Philip Cunliffe-Owen, K.C.B., K.C.M.G., C.I.E., Col. Donnelly, Mr. H. Doulton, Captain Douglas Galton, C.B., D.C.L., F.R.S., Lieut.-Colonel A. C. Hamilton, R.E., Mr. J. M. Maclean, M.P., Dr. R. J. Mann, F.R.C.S , Mr. W. H. Preece. F.R.S., Mr. Owen Roberts, Sir Saul Samuel, K.C.M.G., Lord Sudeley, Sir Richard Webster, Q.C., M.P.

Several special displays of the illuminated fountains took place during the evening.

The Band of the Grenadier Guards, conducted by Mr. Dan Godfrey, performed in the Western Kiosk; the band of the Royal Horse Guards, in the Eastern Kiosk, conducted by Mr. Charles Godfrey; and the band of the 1st West India Regiment, conducted by Mr. W. J. Quord, in the gardens to the east of the Indian Palace. The Royal Handbell Ringers and Glee Singers, under the direction of Mr. Harry Tipper, performed in the Conservatory, and the Glee Choir, from the "Criterion," under the direction of Mr. Richard Mackway, performed in the Indian Palace, and in "Old London."

The number of visitors present at the Conversazione was 9,527.

Proceedings of the Society.

CANTOR LECTURES.

PETROLEUM AND ITS PRODUCTS.

By Boverton Redwood, F.I.C., F.C.S.

[The right of reproducing these lectures is reserved.]

Lecture IV.—Delivered March 29th, 1886.

By far the most important of the uses to which the products of petroleum are as yet applied is that of illumination, and it is to this use that we should accordingly first direct our attention. In regard to the employment of the solid products of petroleum in the form of paraffin candles I have not a great deal to say. Liebig, in 1851, expressed the opinion that "It would certainly be esteemed one of the greatest discoveries of the age if anyone could succeed in condensing coal-gas into a white, dry, solid, odourless substance, portable, and capable of being placed upon a candlestick or burned in a lamp," and it may fairly be said that in the paraffin candle we have a source of light possessing all the characteristics which Liebig considered so desirable. Price's Patent Candle Company and Messrs. J. C. and J. Field are well known to have been conspicuously successful in their efforts to improve the manufacture of paraffin candles, the introduction of the "self-fitting" end, and the adoption of various devices (some of which are illustrated by the specimens on the table) to render the candle more ornamental, being among the many improvements for which the public are indebted to these enterprising manufacturers.

The principal defect possessed by paraffin candles is a liability to bend when exposed to the air of a warm room. This tendency is to some extent overcome by mixing the paraffin with a small per-centage of palmitic or stearic acid, and it is found that candles made of this mixture are also less liable to smoke than those manufactured from pure paraffin. Ozokerit candles have a higher melting point than those which are made of petroleum or shale paraffin, and are in this respect better suited for use in warm climates.

Young's Paraffin Light and Mineral Oil Company have made an ingenious use of soft paraffin in the handy little miners' lamp exhibited.

I am not aware of the existence of any exhaustive account of the various improvements which, from time to time, have been effected in appliances for burning mineral oils with a view to the production of light; and in the attempt to compile a record having any pretensions to completeness, and to collect specimens of the earlier forms of mineral oil lamps, I have met with far greater difficulties than I anticipated, notwithstanding that I have received ready assistance from all the principal firms engaged in the lamp trade, both in this country and abroad.

We know, from the accounts given by historians who wrote prior to the commencement of the Christian era, that petroleum was used as an illuminant in remote ages. The appliances for burning the oil were, without doubt, of a very primitive description, consisting simply of an oil vessel furnished with a wick of some fibrous material. Lamps of this character are still used for burning crude petroleum in various localities. The earthenware petroleum lamp of somewhat artistic form, but very primitive construction, which is now before you, I found in use in provincial Russia, and the little glass and tin lamps I met with in the bazaars in India, where they are sold at the price of one anna.

For the lighting of the derrick during the operation of well-drilling in the United States, the large iron two-spouted kettle-shaped lamp, fed with crude petroleum, is still commonly employed. With none of these lamps is a chimney used, and the flame produced is dull and smoky.

Much interesting and valuable information in reference to the subject of mineral oil lamps was given by Sir Frederick Abel in a lecture delivered at the Royal Institution last year. The lecturer expressed the belief that mineral oil lamps were first constructed in Germany, about the years 1852-3, and somewhat extensive inquiries which I have since made quite confirm this view. Many years previously, however, viz., in 1820, coal-naphtha, produced under Lord Dundonald's patent of 1781, was introduced as an illuminant by Mr. Astley, for use in the so-called founder's blast lamp, in which the combustion was aided by a current of air artificially produced. Read Holliday was also among the first to suggest the employment of coal-naphtha for illuminating purposes, and the vapour lamp which he patented is still largely employed.

Other inventors designed lamps for vaporising coal-naphtha, and burning the vapour at a jet. Various ingenious arrangements for maintaining a uniform oil level were also devised during the latter part of the 18th century. These arrangements, many of which were described by Mr. Leopold Field in his Cantor Lectures on "Solid and Liquid Illuminating Agents," delivered in 1883, were applied to lamps burning fixed oils;* but some are of special interest to us as being applicable to mineral oil lamps. Thus the "bird-fountain" system of maintaining the oil level, which is stated to have been first adopted by Miles in 1781, is applied in one class of petroleum lamps now in use. This arrangement consists of an oil reservoir closed at the top, and communicating by a tube with the wick case of the burner, which is at a lower level than the top of the reservoir. As the oil in the wick case is drawn up to the flame and consumed, a few bubbles of air pass into the reservoir, and a corresponding quantity of oil flows out. The principle of pumping the oil up to the flame, which was devised by Carcel in 1798, is also at present in use in burning mineral oils, chiefly for lighthouse illumination, but also, to a small extent, for domestic lighting.

The first lamps in which mineral oils were burned in this country with any degree of success were those which had been designed some years previously for use with rectified oil of turpentine, known as "camphine." These lamps were constructed upon the principles described by Ami Argand in the specification of the patent granted to him in 1784, and, in view of its great value, it will be interesting to consider the nature of Argand's invention. The specification states that the patent is for "a lamp that is so constructed as to produce neither smoak nor smell, and to give considerably more light than any lamp hitherto known;" and the method by which these results are attained is thus described:— "My method of giving light by lamps, or any other illuminating instruments or things, consists in wholly converting into flame and light any inflammable and combustible matter whatever that may be used as the pabulum, fuel, or subject of such light, which in the common mode of producing light is only in part burnt, consumed, and converted into flame, the rest going off in smoak or soot. This is effected in its various modes of application, first by causing a current of air to pass through the inside of the flame; secondly, by increasing that current of air, and producing another current of air on the outside of the flame by means of a chimney, dome, funnel, tube, pipe, or other contrivance, covering, surrounding, or enclosing the flame, or the vehicle, or the receptacle or vessel containing it, so that the fresh air which continually rushes into the said chimney, dome, funnel, tube, or pipe, or passes through it to supply the place of that which is decomposed and rarified by fire or flame, and which, growing lighter, escapes continually through the top of the said chimney, dome, funnel, tube, or pipe, shall have free access and circulation; or thirdly, by applying such chimney, dome, funnel, tube, or pipe to common wicks, where the full effects of the principle are not required.* This effect of increasing the light, by converting the smoak into flame, is obtained by the means above mentioned, which may be used either separately or, where a greater advantage is required, the methods above described may be combined. The vehicles which contain the light are made of various forms and various materials."

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* I was indebted to Messrs J. and C. Christie for several interesting specimens of these lamps.

The Argand lamp, to quote a description of it published many years ago, "embraces so many improvements upon the common lamp, and has become so general throughout Europe, that it may be justly ranked amongst the greatest discoveries of the age. As a substitute for the candle, it has the advantage of great economy and convenience, with much greater brilliancy; and for the purpose of producing heat, it is an important instrument in the hands of the chemist. We may, with some propriety, compare the common lamp and the candle to fire made in the open air, without any forced method of supplying it with oxygen; while the Argand lamp may be compared to a fire in a furnace, in which a rapid supply of oxygen is furnished by the velocity of the ascending current. This, however, is not the only advantage of this valuable invention. It is obvious that if the combustible vapour occupies a considerable area, the oxygen of the atmosphere cannot combine with the vapour in the middle part of the ascending column. The outside, therefore, is the only part which enters into combustion; the middle constituting smoke. This evil is obviated in the Argand lamp, by directing a current of atmospheric air through the flame, which, instead of being raised from a solid wick, is produced by a circular one, which surrounds the tube through which the air ascends." Argand's original lamp had an iron chimney, but a cylinder of glass was soon substituted. Smethurst, or Lange, afterwards proposed the employment of a chimney with a shoulder or constriction in place of the simple cylinder.

In 1818, Sir Thomas Cochrane obtained a patent for "lamps in streets, which effectuate and regulate the combustion of a certain purified essential oil or spirit obtained from different ligneous, carbonaceous, or bituminous substances usually called spirit of tar, or oil of tar." The principal feature of the invention seems to have been the construction of the "burner or wick-holder of a length proportioned to the volatility of the said essential oil or spirit compared to that of the viscous oil of whales, or of other gross and sluggish oils now in use." In 1822, A. and D. Gordon patented the construction of lamps with wicks made of platinum, gold, silver, or copper drawn into fine threads, or of glass drawn into capillary tubes, bound into a compact bundle; also the use with such wicks of a burning fluid composed of spirit of wine or wood spirit mixed with essential oils. In 1839, Goldsworthy Gurney and Frederick Rixon obtained a patent for the "oleo-oxygen or Bude light, produced by administering to the flame of oil or gas lamps or burners a jet or stream of pure oxygen." In 1840, George Halpin, jun., patented the application of a mechanically produced air blast to an Argand burner, and described the use of "an additional tube placed within that usually forming the inner casing of an Argand lamp." The drawings accompanying the specification also show the construction of a burner with three concentric wicks. In the same year Thomas Young, of Queen-street, London, obtained protection for improved methods of supplying the oil to the burner, and for the use of a perforated plate "at a position above the point of combustion of the wick of lamps, and thereby obtaining a more favourable application of air to the flame of lamps." A year later, a patent was granted to William Newton for "lamps, burners, and apparatus for the production of light and heat for domestic and other useful and ornamental purposes, partly from certain substances which have not yet, to the best of my knowledge and belief, been brought into general use for such purposes and by such means, some of the said substances being the hydro-carbons usually called coal-tar, oils or liquids, naphtha, vegetable tar, oils or liquids, and the liquids obtained by distillation and rectification of the resins, schistus, petroleum, maltha or mineral pitch, mineral naphtha, asphaltum, bitumen, caoutchouc, animal oil, and the various hydrocarbonaceous substances that may be extracted from vegetables, grain, plants, and trees, and most of the inflammable oleaginous or resinous substances that are both to be vaporised at certain temperatures, according as they may vary in nature and specific gravity." The burners in respect of which the use of this remarkably comprehensive list of burning fluids was claimed, were provided with various complicated arrangements for supplying the fluid to the wick, and in some cases for causing the vaporisation of the fluid before its ignition. In the same year (1841) William Young filed a lengthy specification of improvements in lamps, part of which related to arrangements for burning "naphtha or turpentine spirit." William Young's lamp, which was of the Argand type, was at first used with rectified oil of turpentine, known as camphine, but on the introduction of coal oil as an illuminating agent, Young's "Vesta" lamps, one of which, kindly lent me by Messrs. Browne and Co., of Piccadilly, is on the table, were used to burn it. In one form of this lamp two, three, or more flat wicks were so held in curved wick-holders as to produce a tubular flame, and air was admitted to the inner surface of the flame between the wick tubes. A collar of wood was inserted between the burner and the oil reservoir, to prevent the conduction of heat to the latter.

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* It is stated that the use of a chimney had been previously suggested by Quinquet.

In 1842, George Roberts, a miner, was granted a patent, part of which related to improvements in lamps for burning "naphtha, turpentine, or such spirits as are usually burned in lamps." The lamp described in the specification as suitable for use with naphtha or other spirits was of the Argand form, the essential feature of the invention being the use of as many as four perforated disc air deflectors, so arranged as to "deflect air on to the wick, and also on to and all around the flame after it is formed, such deflection of the air being at intervals apart, consequently the air will be deflected on to the flame at different heights, the air being prevented passing into the upper part of the chimney except with the flame." The patentee states that "by combining the use of the four discs, as above described, a lamp, such as above described, may be made suitable for burning naphtha and other spirits, without smoke, producing a very powerful light." This early recognition of the important principle of distributing the air supply is of considerable interest. Three years later, viz., in 1845, the same inventor obtained protection for, among other improvements in the construction of lamps, the use, in the centre of an Argand wick tube, of "a flat disc of metal, to the outer edge of which a curved piece of perforated metal is attached, thus forming a cap through which the air will pass in small streams to the flame;" also for the similar use of a trumpet-mouthed deflector receiving air through a hollow rod, the top of the deflector being closed with a flat disc, and the sides perforated. Air diffusers of similar construction form, as we shall presently see, important features of mineral oil lamps patented later. Mr. Roberts also specified the use of wicks of cane or porous wood, or of asbestos. Samuel King's patent of 1856 relates chiefly to arrangements for providing in a suitable manner a supply of air to the flame of an Argand burner. An additional patent for further improvements in the arrangements for the distribution of the air was taken out by King in 1859. One of King's "Brighton" burners, lent by Messrs. Browne and Co., is on the table. A patent for a chimneyless burner (flat wick) was granted to George Young in 1867.†

Among the lamps on the table are some very interesting specimens kindly lent by Messrs. Bright and Co., successors to the firm of Argand and Co. One of these is a camphene lamp, with central air-tube extending through the reservoir,* and another is a "solar-oil lamp," also with a central air-tube. In the case of the latter lamp, the wick is held in a tube, and through the action of a pin, working in a spiral groove cut in the air-tube, is raised or lowered by rotating the burner collar. The chimney of the solar-oil lamp is slighly conical, and has no shoulder or constriction. I have also to express my indebtedness to Messrs. White, Child, and Co., for the loan of some lamps of considerable historic value.

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* I am greatly indebted to Mr. Edward Phillips for searching the records of the Patent-office and obtaining thus, and by consulting those who have been longest engaged in the lamp trade, much valuable information in relation to the early use of mineral oils for illuminating purposes. Mr. Phillips informs me that Mr. Morris, of the Patent-office, gave him considerable assistance in his search.

† Roberts's "Gem" spirit lamp.

Mr. N. J. Fenner informs me that a turpentine distiller, of the name of Baker, carrying on business on Bow-common, was probably the first to introduce rectified oil of turpentine as an illuminating agent under the name of camphine. This was somewhere about the year 1835. The manufacture of camphine was subsequently, according to Mr. Fenner, carried on by Messrs. Jupp, C. Price and Co., P. Murphy, Flockton, Garton, and Fenner, all of whom were turpentine and rosin distillers, the wet-steam process of rectification being generally employed. In consequence of the high price of colza and fish oils, camphine had at this time a large sale as an illuminant, notwithstanding its liability to fill the room with "blacks" and its many other defects. In 1856, Mr. Chappel, a solicitor, consulted Messrs. Fenner as to commercially utilising an asphaltum imported from Cuba, and experiments having shown that the material yielded 75 per cent. of crude oil from which good burning and lubricating oils could be made, a company was formed and the process successfully carried on for some time, the oil selling at 3s. 7d. to 3s. 8d. per gallon. Before long, however, the introduction of the cheaper American petroleum rendered the industry unprofitable.

The products at first manufactured by James Young were not well adapted for illuminating purposes, attention having been concentrated upon the manufacture of lubricating oils; but in 1853, the increasing consumption of the burning oil which, for three or four years previously, had been manufactured in Hamburg, by Noblée, led Mr. Young to make inquiries which resulted in his finding that suitable burners were being constructed by Mr. C. H. Stobwasser, of Berlin. Mr. Young then obtained some of the burners in question, and entrusted to Messrs. R. Laidlaw and Son, of Edinburgh, the manufacture of similar appliances. Through the courtesy of the present firm of C. H. Stobwasser and Co., of Berlin, I am enabled to place before you historically interesting specimens of the first mineral oil lamps made by Mr. Stobwasser. The earliest of these is on the Argand principle, with an annular wick case, and is called a "solar-oil lamp," while those made subsequently for burning petroleum have flat wick tubes.

Messrs. Stobwasser and Co. inform me that they first made the solar oil (Argand) burners, and the flat-wick burners about 1852 or 1853. The solar-oil burner was constructed for use with the liquid termed "photogene," made by Noblée from coal, while the flat-wick burner was used with the oil distilled from lignite. The solar oil at first manufactured would not burn in the flat-wick burners, as originally constructed, but a slight alteration of the burner, and an improvement in the quality of the oil, overcame the difficulty.

Messrs. R. Laidlaw and Son have also kindly furnished me with the equally interesting specimens of the first burner made for Mr. Young on the German model, and an improved burner shortly afterwards constructed for Young's Paraffin Light and Mineral Oil Company. Both burners have, as you see, flat-wick tubes. Mr. W. Lightbody of the firm of Thomas Rowatt and Sons, has been good enough to furnish me with some valuable information, from which I gather that the business of selling mineral oil lamps, manufactured by Messrs. R. Laidlaw and Son, was commenced by Mr. Young, in Edinburgh, in the year 1857, Mr. Thomas Rowatt, sen., acting as manager. At that time, the burners sold consisted of ⅜ in., ⅝ in., and ⅞ in. flat-wick burners, and 10 l. and 14 l. round burners; such burners as are now sold at 9d. costing 3s.

Gesner states that the first lamps suitable for burning kerosene that were employed in America, were imported from Vienna by Mr. J. H. Austen, who, about the year 1854, was engaged in the coal oil industry. According to Dr. Schweitzer, Professor of Chemistry in the University of Missouri, the coal oil manufactured about this time was of such comparatively high density that it could be burned in ordinary lamps. The subsequent development of the petroleum industry, however, rendered it very necessary to devise special lamps. The first patent taken out for a petroleum lamp, so-called, in the United States, was dated 1859, and in that year forty applications for patents for petroleum lamps, burners, and appliances in general, were granted. In the succeeding year the number of similar grants was 71, in the next year 53, and in the one after 101. From that time to 1878, the number ranged from 63 to 186; and, judging by the number of new kinds of lamps which are every year offered for sale in America, the energy of the American inventor shows no signs of diminution.

Meanwhile, in this country, the improvement of appliances for burning mineral oils was steadily progressing. Messrs. Joseph Hinks and Son, of Birmingham, who had commenced business as lamp manufacturers about the year 1860, patented Oct. 28th, 1865, the well-known duplex burner,* the introduction of which has done so much to popularise the use of mineral oils for illuminating purposes. The patent which was granted to James and Joseph Hinks was described as being for "the improvements hereinafter described in the burners of lamps for burning paraffin oil and other volatile liquid hydrocarbons, whereby two or more flat flames, or one circular, or nearly circular, flame may be produced by the use of two or more single flat wicks." The general construction of the burner was thus described:—" Our invention consists in the employment in the same burner of two or more flat or curved wick cases or holders, in which said cases or holders single flat wicks are placed. Each of the said wick cases is provided with an axis and pinions for raising and lowering the wick therein contained. The wick cases or holders are either straight or slightly curved, or of the figure of semi-ellipses, or semicircular, so as to produce, when arranged in the burner, flat, or elliptical, or circular flames. The cone, or deflector, has two or more straight or curved openings in it, through which the wicks may pass. That portion of the top of the cone between the curved openings (when curved openings and curved wick holders are employed) serves as a substitute for the ordinary button used with circular wicks; or a circular hole may be used in the cone, and the ordinary button employed. When flat wick cases are employed straight openings are made in the cone." In the original form of the flat-wick burner the two wicks were brought together into one wick tube in the lower part of the burner. Subsequent improvements effected by this firm have resulted in the production of a burner, the good features of which are too well known to need enumeration; and I will only call your attention to the conspicuous merit, from an artistic as well as mechanical point of view, of the collection of Hinks lamps on the table. In 1871, Holver Holverstone, of Cambridge, Mass., patented a dual burner, having two flat wicks in a cone furnished with a single slot. Litigation between this inventor and Messrs. Hinks resulted in an amicable arrangement. The dual burners on the table were supplied to me some time ago by Mr. John G. Rollins.

On January 22nd, 1866, Messrs. Thomas Rowatt and Sons patented the "anucapnic" burner, which differs from those already referred to in being provided with a double cone. The use of this appliance admits of the ordinary chimney being replaced by a globe, without any diminution in the brilliancy of the light. The provisional specification, filed by Thomas Rowatt, the younger, states that his "improvements in lamps for burning paraffin, petroleum, belmontine, and other hydrocarbon oils without the use of a chimney," consists in obtaining "the necessary current of air by carrying down a tube of metal or any other suitable material from the dome to within a short distance of the bottom of the burner, extending its lower rim laterally, so that the opening remaining between the edge of this rim and the lower body of the burner becomes an air channel with a much greater superficial area than the area of the bottom neck of the tube, consequently the tube becomes an air-sluice when the lamp is lighted." The specification further states that in order that complete combustion might be effected, it was found that a second current of air must be projected on to the flame above the dome referred to. The arrangement is, therefore, described in the complete specification as consisting of "two round-topped hollow cones or domes, one exterior and the other interior, both being so arranged as to produce two separate and distinct currents of air." Messrs. Thomas Rowatt and Sons patented an improved anucapnic burner in 1878, and in 1882 obtained protection for a duplex chimneyless burner with single-slotted double dome, which they term the "Lorne" burner. In the latter burner the wick tubes are inclined towards each other at the top and bottom, so that the flames coalesce, and the wicks beneath the burner are in contact. Increased luminosity and increased capillary attraction result. Messrs. Thomas Rowatt and Sons have been good enough to provide me with specimens of the three forms of burners. I may here mention that this firm was the first to construct burners with a screw to attach them to the collar of the lamp, the burners previously made in this country being provided simply with a conical tube fitting into the collar.

Young's Paraffin Light and Mineral Oil Company, some years ago, commenced the manufacture of lamps on a large scale, and have introduced several burners of novel and valuable character. Among these are the "Champion" burner, with circular wick, the

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* Dr. Angus Smith had previously constructed a two-wick burner.

"Regulator" burner, and the "Triplex" burner, which is furnished with three flat wicks arranged triangularly. The "Champion" burner was patented by A. E. Ragg, in 1878 and 1880. The claims in the specification of the former patent are for the use of a central perforated cone or tubular chamber within the wick-tube circle for supplying the upper portion of the flame, with a series of small separate injected currents; for the use of a series of rays or divisions projecting from or approaching close to the wick-tube or tubes, "so as to separate the impinging current of air into a series of currents separated by quiescent intervals, thus causing serrations in the flame;" for the mode of "preventing smoke in lamps by adjusting the cap to that height above the surface of the wick, that on the cap being placed in position the flame changes from yellow to white;" and for the use of two flat wicks in an Argand burner, in such a manner that they are brought to a cylindrical contour at the top. In the specification of the subsequent patent the claims are for the use of a disc or button (either alone or in conjunction with a perforated tube), of such size as to extend over the entire area embraced by the inner wick tube, and the greater portion or whole of the wick, "so as to deflect the flame outwards to a much greater extent than heretofore, and at the same time to cause the central current of air to be deflected into the flame above the wick with a correspondingly greater force." Under this patent, improvements in the construction and fitting of the air chamber and gallery, and an arrangement for regulating the level of the oil, are also claimed as novelties. The patent for Ragg's "regulator" burner, dated 24th October, 1878, is based upon his other patent of the same year (dated 3rd June) already referred to. A considerable portion of the specification relates to improvements in the method of constructing the wick tubes so as to admit of the use of two flat wicks as described. One claim is, however, for the "regulator," which consists of a cap attached to the cone, and so formed that is covers up a portion of the wick, and excludes it from the action of the flame. "It is preferred that the portion of the wick covered up shall be the extreme ends." The inventor states that this addition to the burner regulates the height to which the wick may be turned up, and thus prevents it from being turned up high enough to cause the throwing off of smoke or unconsumed carbon, and ensures a uniform and perfect trimming of the wick. The unconsumed portion of the wick protected by the "regulator" is also said to act as a feeder to the flame, so that in the use of the lighter oils the flame is maintained of full size for a greater length of time, while oils too heavy for use in lamps of the usual construction are caused to burn satisfactorily. An additional claim is for a chimneyless flat-wick burner, provided with a shallow trough placed above the wick-tube, and with the bottom cut away over the wick. This trough becomes heated, and is stated to deflect the air currents so as to produce a broad flame. The "Triplex" burner was patented by Doty, in 1876, the claims being for the arrangement of three flat wicks triangularly; for the "flaring" or outward inclination of the wick-tubes; and for the construction of the cap with three intersecting hemispheres. I am indebted to Mr. John Fyfe, Managing Director of Young's Paraffin Oil Company, for specimens of the lamps described, and for much valuable information regarding their construction.

Mr. A. M. Silber is well known to have devoted a large amount of time and attention to the improvement of mineral oil burners, and has published the results of his efforts in an instructive paper read before this Society in 1870. The excellent results obtained with the Silber burner, which is of the round, or Argand form, are due largely to the use of an inner tube so constructed and placed as to direct a current of air on to the inner surface of the flame at a point some distance above its base. Professor Barff has stated that the prismatic spectrum of the light emitted by this burner is nearly identical with that of the solar ray; it should, therefore, allow nearly all shades of colour to be distinguished as in daylight.* The Silber burner with central tube was patented in April, 1873, and the claim specified is for "the improved burner hereinbefore described, in which there are one or more air-tubes receiving atmospheric air through apertures in their sides or peripheries at the lower part thereof, substantially as described." Two years previously Mr. Silber patented a lamp provided with an annular air-space passing vertically through the body of the lamp between the wick chamber and the oil reservoir. Oil was supplied to the wick through several small tubes connecting the base of the oil reservoir with the wick case, and thus the main body of the oil was kept cool, while the small quantity supplied to the wick became considerably heated. I am indebted to Mr. A. M. Silber, and to Mr. J. J. Collins, for some of the particulars given; and to Messrs. Silber and Fleming for the loan of the specimens of the Silber lamps exhibited.

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* This remark would, no doubt, be equally applicable to the light given by other mineral oil lamps of modern construction.

Sugg's "Westminster" burner has, as you may see on examining the specimen exhibited, wick tubes of steatite.

Among those who have done much to improve petroleum lamps are Messrs. Wright and Butler, to whose lamps and stoves for warming and cooking I shall have occasion again to refer. I am indebted to this firm for furnishing a large collection of lamps.

The lamp which has been recently introduced by Messrs. J. Defries and Sons has several valuable characteristic features, to some of which I shall have occasion to refer later. It is on the Argand principle, and is the invention of Mr. Sepulchre. The air passes to the interior of the flame through the base of the lamp, and the wick is contained in an annular space formed by the air-tube (which passes completely through the oil reservoir) and an outer tube attached to the burner collar. The latter tube reaches nearly to the bottom of the oil reservoir, and, being slightly longer than the wick, is always sealed by the oil. Thus the passage of flame from the burner to the air space of the oil reservoir is prevented, and the oil cannot flow out in the event of the lamp being overturned. Messrs. Defries have contributed several specimens of this excellent lamp.

The "Lampe Belge," exhibited by Messrs. Palmer and Co., has a similarly placed central air-tube, but is not provided with the long outer wick-tube. The "Excelsior" lamp supplied by this firm has an Argand burner with two flat wicks, which, meeting in the wick case, furnish a tubular flame. The wicks are fixed in wick-holders sliding in the wick-tube, and are raised or lowered by a rack and pinion.

Messrs. Dietz and Co. have supplied me with the specimens exhibited of their well-known "Paragon" burner, and other burners for mineral oils.

The Albion Lamp Company, of Birmingham, who are well known as the largest manufacturers of mineral oil stoves, have furnished me with specimens of their "Empire" and "Peerless" chimneyless burners.

I am also indebted to Messrs. Williams and Bach, to Messrs. Barclay and Son, to Messrs. Messenger and Son, to Mr. George Mordaunt, and to Mr. J. Rowe, for the loan of a number of specimens of lamps.

I have on the table a representative collection of American lamps, for the loan of some of which I am indebted to Sir Frederick Abel. The "Waterbury" lamp has an Argand burner provided with an ingenious arrangement for facilitating the insertion of the wick, and with an equally ingeniously contrived extinguisher, to which I must again refer. The "Star" lamp is also on the Argand principle, and has the annular air-space, surrounding the wick-tube and passing through the oil reservoir, that I have already described as having been patented by Mr. Silber several years ago. It is an objection to lamps so constructed that the oil creeps over the upper edge of the wick-tube, and it has accordingly been found necessary to provide a drip-cup in the base of the lamp. A later form of the "Star" lamp, manufactured by Holmes, Booth, and Hayden Co., New York, and contributed by Messrs. Lotz, Abbott, and Co., has a good extinguisher. One of the Argand burners shown (patented by J. Funck in 1882) has a long inner wick-tube, extending almost to the bottom of the cylinder, which serves as an outer wick-case. The wick is held in another long tube of thin metal, to which is attached a stud working in a spiral groove made in a fourth tube extending downwards from the collar which supports the cone. The tube which holds the wick is revolved by a pinion working in teeth cut in the lower edge of the cone; and through the action of the spiral groove, the wick is thus raised or lowered. Of the various flat-wick burners shown, the "Sun-hinge" is so made that, without removing the chimney, the cone can be raised like the hinged lid of a box, for trimming the wick or lighting. Another, the "Manhattan," an exceedingly good burner giving a tall, well-shaped flame, is provided with two cones. The principal general features of the American flat-wick burners are the comparative thinness of the metal of which they are constructed, and the shortness of the wick-tubes.

Both in this country and in America flat-wick burners have hitherto been far more largely used than Argand or round burners. On the European continent, on the other hand, flat-wick burners are rarely employed. The commonest form of German round burner is that which is known as the "Cosmos." This burner has, as you see, neither the additional inner tube nor the button, and accordingly it is necessary to use with it a chimney much constricted a short distance from the base. Better results, especially with the larger sizes, are obtained with the improved burners supplied by Messrs. C. H. Stobwasser and Co., Messrs. Wild and Wessel, and Messrs. Schuster and Baer, under the names of the "Victoria," the "Phœnix," the "Moon," the "Helios," and the "Solar-oil" burners. These improved burners differ from the old form of "Cosmos" burner principally in being provided with an air-tube within the inner wick-tube, or with a button to deflect the inner air current.

The Russian burners placed before you are manufactured by Kumberg. They differ only in details of construction from those which I have described. One of the Argand burners and the flat-wick burner are intended for use with the heavier oils. The latter burner has a short but capacious wick-tube, and takes a wick of unusual thickness. The former burner has a slightly conical chimney held in position by a metal collar fitting over its base. In 1884, the Committee of the Russian Chemical and Physical Society awarded to Kumberg the premium which had been offered for a lamp suited to Caucasian oils of specific gravity ·865 to ·875.

In the construction of all mineral oil lamps, the principal points aimed at are the production of a current of air passing into the burner with suitable velocity; and the direction of this air-current on to the flame in a manner best adapted to secure the proper combustion of the oil. The heated chimney or other arrangement induces the required flow of air, but if in the case of an Argand lamp the chimney be cylindrical and the burner merely two tubes to hold the wick, the air would not do what is required of it, and the lamp would burn with a flame of comparatively little luminosity. In the simplest forms of flat-wick burners the metallic dome which surrounds the top of the wick-tube serves to cause the air-current to impinge upon the flame, the base of the burner being fitted with a disc of perforated metal to moderate the velocity of the current. In the best round burners the result is attained by the use of a metallic disc or other contrivance, sometimes in conjunction with a cone surrounding the wick-tube; or as in the Silber lamp, and other lamps, by the use, in addition to the cone, of an inner air-tube of suitable size and form. The "air diffuser" of the Defries lamp (Sepulchre's patent) may be described as a combination of the button and a perforated tube closed at the top, while the air diffuser of the "Rochester" lamp and of Young's "Champion" burner consists of a cylinder closed at the top and with perforated walls. The action of the button or tube is aided by the employment of a chimney formed with a shoulder, and if the chimney be constricted just above the top of the burner, the use of the button or tube may in fact be dispensed with. The upper part of the Bayle chimney is in the form of a truncated cone, the chimney practically consisting of two cones united at their smaller ends. It is claimed that the employment of this form of chimney causes the outer air-current, entering between the glass and the wick-tube of an Argand burner, to pass upwards with the same velocity as that of the inner current which supplies the centre of the flame with air. I have already referred to the use of the double cone of the anucapnic lamp, as a substitute for the chimney. Lamps are made in which the air current is supplied by a revolving fan, driven by clockwork in the base of the lamp; this method of construction being illustrated in the lamp exhibited by Messrs. Gardners. Martin Rae, in 1861, patented the use of a small lamp in the base of the lamp proper to create a current of air, the use of a flame "of the size of a common pea" being, he states in his specification, "sufficient to rarify the air of a lamp with a flame of two inches square."

The "blast lamp," patented by Robert Lavender in 1875, and introduced by Young's Paraffin Oil Company for use in illuminating large spaces in the open air, was provided with an arrangement for introducing a jet of steam into the chimney, on the principle of the "blast" employed in locomotives, and thus producing a strong upward current of air, suitable for the combustion of the heavier mineral oils.

In the case of Argand oil burners, it may be said that there are four principal points at which the air currents impinge upon the flame. Thus as regards the interior surface of the flame, the current of air first comes into contact with the base of the flame, while a portion is, by the use of a deflector or central tube, or other contrivance, caused to strike the flame at a higher point. Similarly as regards the outer surface of the flame a portion of the air current meets the flame at its base, and another portion comes into contact with the flame surface higher up. As we shall presently see, when considering the subject of lighthouse illumination, Sir James Douglass's mineral oil burner has a cone provided with three openings for air, at gradually increasing heights from the base, and the air is thus supplied to the exterior of the flame in comparatively small quantities at different elevations.

Scarcely less important than the production and direction of the air current is the maintenance of a proper supply of oil to the flame. With most mineral oil lamps this is effected through the unaided capillary attraction of the wick, and it is obvious that the quality of the wick is a point of great importance. To this, however, I propose to refer later. In the student or reading-lamp the action of the wick is aided by maintaining a constant level of oil on the principle of the bird fountain already mentioned. The principle of the "Moderator" lamp is also sometimes applied to lamps for domestic use, as in the Peigniet-Changeur lamp shown at the International Health Exhibition, the oil pumped up being however allowed to overflow at a lower level in the wick-tube than in the case of colza oil. Mr. Silber has proposed to lay on a supply of oil to the various burners throughout a dwelling house from a reservoir on each floor, kept filled from a storage tank, the supply being regulated by the use of ball valves. Peter Brash and William Young patented a similar arrangement in 1867, and Mr. D. C. Defries has recently patented a method of arriving at the same result. Messrs. Hinks some years ago manufactured a lamp in which the oil container from which the wick drew its supply could be caused to descend into a well or reservoir forming the base of the lamp, and could thus be refilled. In some lamps the action of the wick proper is aided by the provision of a "wick-feeder," consisting of a thick and loosely woven wick attached to the under surface of the burner, in contact with the wick proper, and dipping into the oil.

The wick is usually raised or lowered in the wick case by the action of toothed wheels pressing lightly against it, the revolution of the wheels being effected by turning a button on the end of a spindle which carries them. In some instances, however, the wick is held in a tube, or frame, which is raised or lowered by a rack and pinion, or by a worm cut on the burner tube, and actuated by revolving the burner, or, as in the "Rochester" lamp, by means of a vertical rod attached to the wick frame. The flame has always hitherto been produced from the extremity of the wick, but an arrangement for presenting a fold of a continuous flat wick as the burning surface was shown in the International Inventions Exhibition. The burner thus fitted was provided with a device for causing the wick to travel through the burner so that a fresh portion of wick could be exposed when desired.

The wicks at first employed in lamps for burning fixed oils were of the nature of a loosely woven cord or solid cylinder. In 1773, Leger used a flat wick, and a few years later Argand adopted a tubular wick. Ditmar and others have used two wicks; one to bring the oil up to the burner, and the other to burn it. With a large number of the round burners of the present day, a flat wick of such breadth that the edges meet in the annular wick space is employed, and in some instances two flat wicks are similarly used. The "Mitrailleuse" burner is, however, furnished with a number of solid cylindrical wicks, arranged in a circle, and held in a frame, which is raised or lowered by a rack and pinion. Specimens of this form of burner, supplied by Messrs. Browne and Co., and by Mr. Rettich, are on the table. The Rettich "Mitrailleuse" burner has, I may point out, an air deflector of improved form. The "Sirius" burner, patented by Morrison and Smith, and one form of the "Martin" burner, are provided with two concentric wicks; but compound Argand burners are, for the most part, used only for lighthouse illumination.

Considerable attention has, for some years been paid to the construction of wicks in the United States, and last autumn I was afforded the opportunity of inspecting the process of wick manufacture at a factory in Troy. On the table is a set of specimens (with which I have been supplied by Mr. Dowd) illustrating the method of wick construction adopted in the United States. The various operations, in the order in which the cotton is subjected to them, are in the United States termed:—(1) opening; (2) lapping; (3) carding; (4) railway drawing; (5) doubling and first drawing; (6) doubling and second drawing; (7) slubbing and roving; (8) speeder roving; (9) spinning; (10) twisting, which makes the yarns ready for the looms.

I am indebted to Mr. Herbert Morgan, of the firm of Joseph Morgan and Son, of Manchester, who manufacture mineral oil lampwicks more largely than any other firm in this country, for the following particulars, and for a complete collection of illustrative specimens:—

"The raw cotton employed in the construction of a wick should be a good quality of American, carefully selected, and of long staple. The length of the staple forms a very important feature, as this to a large extent governs its capillary attraction. The cotton should be spun into what is known as coarse counts, because it can be easily understood that a fine thread cannot draw the oil with anything like the same power that a coarse loose thread can. When spinning, great care must also be taken to see that only sufficient twist is put into the yarn to enable it to pass through its succeeding processes, as all twist over and above this necessary quantity, will be detrimental to its burning power. Here again the benefit of the long staple is at once evident. A short staple cotton must require extra twist to give it sufficient strength to make up for its deficiency in staple, whereas the long staple cotton will have the required strength with the minimum of twist. After we have got the raw cotton into the single yarn, it must then be doubled into its requisite number of folds, two, three, or more ends as the case may be, and here again great care is required in the doubling process to prevent undue twist, for the same rule applies exactly in this process as in the spinning process. If more twist is put into the yarn in its doubled state than is required to pass it through the weaving process which immediately follows, this excess of twist will injure the quality.

"We have now got the cotton into the doubled state ready for being made into warp, and here we will more fully explain the component parts of a wick, so that their technical terms may be clearly understood. There are two recognised ways of manufacturing a wick; the easier one of the two, and the one generally adopted, is to make a wick of only three distinct parts. First of all the 'warp,' which means the coarse threads running perpendicularly through the wick and seen distinctly on the outside. Next the very fine threads of cotton passing through the centre of the wick, which work from top to bottom, and bind the two surfaces of the wick together. These are called 'binders,' and are plainly seen in the sample, wherein they have been coloured mauve, one side of the wick having been removed to show their internal position. If the wick were woven without the binders, it would be simply a circular wick and not flat. Next we come to the 'weft,' which is the fine cross threads in the wick, seen on the surface, passing under and over the warp, holding the warp threads and binders in their proper position, and this completes the construction of an ordinary wick.

"The second mode of manufacturing a wick is exactly as we have already stated, but with one addition, and this we take to be a most important part of a really good wick. In addition to the binders, which we have said before pass through the centre of the wick and hold the top and bottom together, are placed what are known as 'gut' threads. These threads run perfectly straight through the centre of the wick in the same direction as the warp-threads, but are not crossed or interfered with in any way, either by the weft or the binder. They can be drawn out from the wick without any perceptible difference being made in its external appearance, showing that although they form part of the wick they are totally distinct and independent of it. In the 'duplex' size, which is perhaps the one most universally known, the number of gut ends should be twelve, and among the samples are wicks woven both with and without the gut threads. One sample has had part of its warp or outside portion removed, so as to show distinctly the exact position that the gut occupies, and also the appearance of the wick when constructed without gut. We claim for these gut threads that as they pass direct from the oil to the flame without any impediment whatever, they must prove a most important auxiliary to the capillarity of the wick, and materially assist its burning power.

"The weft employed in wick making should also receive careful consideration, and be made from a good quality of single cotton, two or more fold; hard twisted yarn, such as is often employed, being highly detrimental to the free flow of oil. The weft is easily seen, as already indicated, on the surface of the wick as it crosses the warp-threads, and the number of these cross threads per inch should not exceed thirteen, except in the case of very broad wicks, although in some samples we have seen sixteen, and even more are put in, but these are unnecessary, and only retard the flow of oil to the flame. In constructing a wick, it is only necessary to make it of sufficient firmness to wind properly, and when you have got the required resisting power to the racks, all over that is detrimental, and not one pick of weft over the number which is absolutely necessary should be inserted.

"But to return to the warping process. This there is nothing special about, as the cotton has simply to be put together in warp of the required number of ends to make the width of wick wanted. The warp when made is taken to the loom and woven into wick. After the wick leaves the loom, a most important process should take place, as on this depends, to a very large extent, whether you will reap the full benefit of the care already bestowed on the wick in its manufacture. We refer to the boiling process. It will be seen that in the number of processes through which the cotton is compelled to pass from its raw state until it appears as a woven wick, there must of necessity pass into it a considerable amount of impurity. This it is quite impossible to avoid, seeing that it goes through no less than twelve distinct preparations. These impurities consist of the natural oil in the cotton, and particles of dust and dirt which are always flying about machinery when in motion, and should without doubt be entirely removed before the wick is to perform its duty in the lamp, and they must be removed in such a way as not to injure in any degree the cotton of which the wick is made. It will readily be seen that the wick really acts as a filter, through which the oil must pass on its way to the flame, and unless a wick is absolutely pure to begin with, it is utterly impossible for it to perform its duty properly. If in this boiling process, chemicals of any description are used, either to improve the colour of the wick or to act more stringently upon it, just to that extent will the fibre of the cotton be injured, and its burning power reduced. By continued experiments and practice it has been found that wick boiled in pure spring water gives the best result. The impurities of the wick will, during this process, pass into the water, and, to a certain extent, discolour it, and float upon the surface. After this boiling bath, which varies in duration according to necessity, the wick should be thoroughly rinsed in cold water, and then put into a hydro-extractor before being removed to hot closets heated to about 130 degrees. It is kept at this temperature until perfectly dry, and without a particle of moisture remaining in it. The only process that now remains to be done is to make the wick up into its required state for the market, either in rolls or in cut lengths, and it is now ready for use.

"Perhaps it will be interesting to mention, in detail and briefly, each of the separate processes through which the cotton passes during its course of manufacture. We first of all have the cotton in its raw state as received in the bale from America. The machine it enters first is called an 'opener,' for breaking up the cakes into which the cotton has been formed by the pressure of the hydraulic packing. When this is done, it passes to a machine called the 'scutcher,' which removes the sand and seed, and then coils the cotton into the form of a 'lap,' ready for the next process, termed 'carding.' This removes the lighter vegetable matter, such as broken seeds, dead leaves and motes, and also disentangles the knotted fibres, and delivers the clean cotton into a 'can' ready for the 'drawing frame,' through which it next has to pass. By passing through this machine, the cotton gains much greater regularity and uniformity of weight. We next come to the 'slubbing frame,' which receives the cans of cotton from the drawing frame; these are passed, without doubling, through this frame, being drawn out to four or five times their original length, and after being slightly twisted, are wound on to bobbins. To give the cotton greater regularity and finish, it next passes through what is called the 'intermediate frame,' which is a repetition of the process of the slubbing frame. The bobbins from this intermediate frame are then passed on to the 'roving frame,' which draws off two bobbins together, and forms a 'roving' about one-third the thickness of the slubbing. It here receives a further small amount of twist, and passes on to the roving bobbin. The roving bobbins are then placed in the creel of the mule, and passed through the rollers without doubling, but with a draught of about 8 to 1, which means that the yarn is drawn out to the extent of about eight times its original length, producing a thread one-eighth of the thickness of the roving, and here it receives the amount of twist required for the purpose for which the yarn is intended, and on leaving the rollers, is wound on to the spindle in the form of a 'cop,' which constitutes a perfect yarn in the single state. These cops are in their turn taken to the doubling frame to be doubled two, three, or more ends together as may be required. This doubled yarn is then taken to the warping frame, and the requisite number of ends being put together, for whatever width of wick may be required, is then made into the warp; the warp being taken to the loom, where it gets woven together with the binder, gut, and weft; these four uniting in this weaving process, and forming a perfect wick."

It is important to dry the wick before it is used, and I may take this opportunity of stating that wicks are frequently found to have absorbed from 4 to 6 per cent. of their weight of moisture, and to the extent to which this moisture is present, the capillary attraction of the wick when used in the lamp is impaired. The following results of experiments which I have made with wicks of various qualities in common use, clearly indicate the importance of employing a wick of good quality. The figures indicate the relative quantities of a given oil of good quality, drawn through wicks of the same width, by capillary attraction, in a given time:—

Wick of best quality	198
Wick of medium quality	100
Wick of inferior quality	76

The extent to which the behaviour of the lamp is affected by the quality of the wick, especially with oils that do not flow very freely under the influence of capillary attraction, is strikingly shown by the following results which I obtained under otherwise similar conditions:—

	Wick of best quality.	Wick of ordinary quality.	
Maximum illuminating power	10·43	9·99	Standard candles.
Minimum illuminating power after six hours' burning....	9·63	7·64	
Average illuminating power during six hours' burning..	10·14	8·99	
Diminution in illuminating power, per cent.	7·6	23·5	
Oil consumed per hour......	529	500	Grains.
Oil consumed per candle-light per hour	52·17	55·61	

Many of the complaints of unsatisfactory burning quality of oil have undoubtedly arisen from the use of inferior wicks. As an illustration of the ignorance which frequently prevails as to the importance of using a good wick, I may mention that an American friend, engaged in the petroleum trade, being unable to account for the reiterated statements of a customer that the oil supplied would not burn, caused an examination to be made of the lamp in which the oil was used, and found that the wick having become short the complainant had ingeniously lengthened it by attaching with two pins a strip torn from an old flannel garment. This arrangement appeared to have answered the purpose fairly well until one of the pins fell out unperceived, when the surfaces of contact of the flannel and wick were no longer sufficiently large, and the lamp having ceased to burn, the oil was hastily assumed to be in fault.

In certain cases, however, it is found that a wick gives satisfactory results for several days and then appears to become choked. Even in such cases, however, the use of a sufficiently good wick overcomes the difficulty, as is shown in the following tabular statement of the results of some experiments made two years ago. For convenience of comparison, I have expressed the illuminating power at the commencement of the experiment as 100 in each case :—

	Wick of best quality.	Wick of ordinary quality.
Maximum illuminating power when the wick was new	100	100
,, ,, ,, after the wick had been used for a total of 21 hours on 3 successive days	—	58·5
,, ,, ,, after the wick had been used for a total of 32½ hours on 5 successive days	—	17·8
,, ,, ,, after the wick had been used for a total of 50 hours on 7 successive days	93·8	—

Mr. Nakamura formed the opinion that this choking results from the deposition of water in the wick, since the wick recovers its capillary power on drying. Among those who have experimentally investigated the subject of the diminution in illuminating power in petroleum lamps are Colonel Junker, director of the Test-Bureau of the Bremen Petroleum-Börse, Mr. L. Schmelk, chemist to the Norwegian Sea-lighting establishment, and Dr. J. Biel, of St. Petersburg.

While on the subject of wick manufacture, I may point out that it is much to be desired that lamp manufacturers would adopt standard gauges for the wick-tubes. At the present time an unnecessarily large number of wicks, varying in thickness and in width by sixteenths of an inch, have to be made and kept in stock, and since the nominal widths of the wick-tubes sometimes differ to a considerable extent from the actual widths, it frequently results that the wick supplied does not fit the tube properly. The wicks in use in this country with mineral oils range in width from 1-4th of an inch to 5 inches, the greatest difference in width between any two of the intermediate sizes being 1-4th inch, and the difference being, as I have said, in many cases as little as 1-16th inch. There is also considerable variation in different burners in regard to the thickness of the wick which the holder will properly take. If the wick is too narrow, the lamp will not burn well, and its use may even be dangerous. If the wick be too thin, it is deficient in capillary attraction, and if too thick will not move freely.

Several kinds of incombustible wicks have at various times been introduced. I have already referred to the use of metallic and glass wicks. The wick patented in 1876, and in an improved form in 1877, by Heinrichs, with which the reading lamp on the table is fitted, consists of a lower portion of felt, an intermediate portion of mineral wool, and an asbestos tip or ring. In the International Inventions Exhibition last year, a lamp with an asbestos wick patented by Messrs. Flatau and Turner was shown. One of the claims in the patent specification relating to this lamp is for the division of the wick horizontally into two portions, one of which can be moved up or down so as to be put into or out of contact with the other portion. The inventors appear to prefer that the upper part of the asbestos wick should be a fixture in the wick-tube, and that the lower part should be moved downwards out of contact with the upper part when it is desired to extinguish the lamp.

It is now usual to fit the larger burners with some form of extinguishing apparatus. The earliest attempt to fit an extinguisher that has come to my knowledge was made in the case of the improved "Brighton" burner, patented in 1862. This burner, a specimen of which has been contributed by Mr. E. I. Moon, has an air-deflector or button, the stem of which rests upon a pin passing horizontally through the burner. On withdrawing the pin, the button drops on the wick and extinguishes the flame. In the "Waterbury" burner, the dropping of the button is also effected by drawing out a pin, but the action compresses a spring, and the button resumes its normal position on the pin being released. The button extinguisher of the new "Star" lamp is brought into action by depressing a thumb plate, and in this case also the button returns to its original position when the pressure is removed. The "Duplex" burners of Messrs. James Hinks and Son, Messrs. Wright and Butler, and others, are fitted with ingeniously contrived extinguishing apparatus, which, on depressing a lever, bring a pair of metallic plates into contact over the top of each wick-tube. In one of the "Duplex" lamps shown by Messrs. Wright and Butler, the extinguisher is automatically brought into action as soon as a weighted rod suspended beneath the burner passes to any material extent out of a line perpendicular to the base of the lamp. It is therefore impossible for the lamp to become tilted when falling without the flames being extinguished. An automatic extinguisher has also been patented by Messrs. King and Godfrey.

Two of the "Duplex" burners and Rettich's "Mitrailleuse" burner are provided with mechanical arrangements for raising the gallery carrying the chimney and globe, so that the wicks may be conveniently lighted. In Wright and Butler's "Duplex" the gallery is supported on levers, which, on turning a key, not only raise the chimney and globe, but also move them to some extent horizontally. In Hinks' "Duplex" the movement of the gallery, effected by turning the key, is vertical only. In Rettich's "Mitrailleuse" there is no key action, but the gallery slides up to an extent sufficient to admit of inserting a lighted taper.

Messrs. C. H. Stobwasser and Co., of Berlin, have recently adopted a process for preventing the oil from "creeping" over the edge of the burner collar and soiling the exterior of the reservoir. The process consists in placing in the collar, between the edge of the reservoir and the plaster of Paris which is used to attach the collar, a layer of some compound which looks like a mixture of gelatine and glycerine. The oil will pass through the plaster, but is arrested by the compound referred to. The upper surface of the collar of the lamp is also made slightly conical, and at its inner and lower edge, at the junction between the collar and the burner, a small hole communicating with the oil reservoir is made. Any oil, therefore, which drops from the burner returns to the reservoir. On the pin of the wick-winder is soldered a small star-shaped wheel, the points of which are over the conical collar. Oil passing along the pin is stopped by the star-wheel, and drops from its lowest point on to the collar.

We have now to consider the principles of construction of mineral oil lamps in relation to the question of safety. This subject has been dealt with by Sir Frederick Abel, who, in the lecture already referred to, gave the results which have been so far arrived at in the course of an experimental inquiry on which we are still engaged. It is well known that accidents in the use of mineral oil lamps are, unfortunately, of by no means rare occurrence, though the number bears a very small proportion to that of the lamps in use. The attention of authorities and experts in the United States has long since been directed to the comparative frequency of such accidents, and Dr. Chandler, of New York, as long ago as 1871, published a report of a lengthy series of experiments which he had undertaken with the object of ascertaining the conditions under which the accidents occurred. It seems, however, to have been somewhat hastily assumed that the accidents were the result of explosions of the mixture of petroleum vapour and air formed in the upper part of the oil-container, and the experiments were therefore chiefly directed to ascertaining the relation between the flashing point of the oil and the temperature to which the oil was raised when burning in various forms of lamps. Commenting on these experiments, Mr. Peckham very properly points out in his census report that, although explosions undoubtedly sometimes break lamps, the danger arises principally from the risk of overturning and breaking the lamp.

In a previous lecture, delivered at the Royal Institution eleven years ago, Sir Frederick Abel stated that a large proportion of the accidents arising out of the use of mineral oil lamps were not actually due to the occurrence of explosions; and in the subsequent lecture he added, that instances might be quoted in which the breaking out of a fire, or the destruction of or injury to life, which had evidently been caused by upsetting or allowing to fall a mineral oil lamp, had been erroneously ascribed to an explosion. There are, however, as Sir F. Abel said, numerous cases of accidents which have been caused by explosions in lamps, followed by the ignition of the oil. The experiments which have been made by Sir Frederick Abel and myself, with the valuable aid of Dr. W. Kellner, Assistant Chemist of the War Department, have enabled us to arrive at several definite conclusions with respect to the immediate causes of lamp explosions, and to certain circumstances which may tend to favour the production of such explosions. These conclusions were so clearly set forth by Sir Frederick Abel, that I cannot do better than quote his remarks verbatim :—

"If the lamp of which the reservoir is only partly full of oil, be carried or rapidly moved from one place to another, so as to agitate the liquid, a mixture of vapour and air may make its escape from the lamp in close vicinity to the flame, and, by becoming ignited, determine the explosion of the mixture existing in the reservoir. This escape may occur through the burner itself, if the wick does not fit the holder properly, or through openings which exist in some lamps in the metal work, close to the burner, of sufficient size to allow flame to pass them readily. A sudden cooling of the lamp, by its exposure to a draught, or by its being blown upon, may give rise to an inrush of air, thereby increasing the explosive properties of the mixture of vapour with a little air contained in the reservoir, and the flame of the lamp may at the same time be drawn or forced into the air-space filled with that mixture, especially if the flame has been turned down, as the latter is thereby brought nearer to the reservoir. The sudden cooling of the glass, if it had become heated by the burning of the lamp, may also cause it to crack if it is not well annealed, and this cracking, or fracture, which may allow the oil to escape, may convey the idea that an explosion has taken place. If the evidently common practice is resorted to of blowing down the chimney with a view to extinguish the lamp, the effects above indicated as produceable by a sudden cooling may be combined with the sudden forcing of the flame into the air space, and an explosion is thus pretty certain to ensue, especially if that air-space is considerable. If the flashing point of the oil used be below the minimum (73° Abel) fixed by law, and even if it be about that point or a little above it, vapour will be given off comparatively freely if the oil in the lamp be agitated, by carrying the latter, or moving it carelessly; the escape of a mixture of vapour with a little air from the lamp, and its ignition, will take place more readily, but, on the other hand, it will probably be feebly explosive, because the air will have been expelled in great measure by the generation of petroleum vapour. If the flashing point of the oil be high, the vapour will be less readily or copiously produced, under the conditions above indicated, but, as a natural consequence, the mixture of vapour and air existing in the lamp may be more violently explosive, because the proportion of the former to the latter is likely to be lower and nearer that demanded for the production of a powerfully explosive mixture. If the quantity of oil in the lamp reservoir be but small, and the air-space consequently large, the ignition of an explosive mixture produced within the lamp will obviously exert more violent effects than if there be only space for a small quantity of vapour and air, because of the lamp being comparatively full. If the wick be lowered very much, or if for some other reason the flame becomes very low, so that it is burning beneath the metal work which surrounds and projects over the wick holder, the lamp will become much heated at those parts, and the tendency to the production of an explosive mixture within the space of the lamp will be increased, while, at the same time, heat will be transmitted to the glass, and it will be correspondingly more susceptible to the effects described as being exerted by its sudden exposure to a draught. Experiments have demonstrated that a lamp containing an oil of high flashing point is more liable to become heated than if it contained a comparatively light and volatile oil, in consequence of the much higher temperature developed by the combustion, and of the comparative slowness with which the heavy oil is conveyed by the wick to the flame. It therefore follows that safety in the use of mineral oil lamps is not to be secured simply by the employment of oils of very high flashing point (or low volatility), and that the use of very heavy oils may even give rise to dangers which are small, if not entirely absent, with oils of comparatively low flashing points."

Miscellaneous.

COLONIAL AND INDIAN EXHIBITION.

TESTIMONIAL TO THE PRINCE OF WALES, K.G.

In response to a general wish that steps should be taken to give expression to the appreciation which all those who are connected with the Colonial and Indian Exhibition feel for the deep interest which His Royal Highness the Prince of Wales, Executive President of the Royal Commission, has evinced in the undertaking, a meeting was held on Wednesday, the 14th July, at the residence of Earl Granville, which was attended by Members of the Royal Commission, the Executive Commissioners for the Colonies, and India and others.

Earl GRANVILLE having taken the chair, and having briefly explained the objects of the meeting, it was proposed by Lord IDDESLEIGH, seconded by Sir CHARLES TUPPER, High Commissioner for Canada, and unanimously resolved :—

"That the eminent services of His Royal Highness the Prince of Wales, in the promotion of the Colonial and Indian Exhibition, ought to be marked in some fitting manner:—That the members of the Royal and of the Colonial Commissions believe that the gentlemen who have been connected with the work, both in the Colonies and in India, would desire to share in the public appreciation of His Royal Highness' service; and it is accordingly considered that a piece of plate, commemorative of the Exhibition and of the great interest which his Royal Highness has practically evinced in its success, should be obtained for presentation to him."

On the proposition of Lord CRANBROOK, it was resolved:—

"That a subscription list be opened both here and in the Colonies and India for the above purpose; and that, inasmuch as it is desirable that the participation in this public tribute to his Royal Highness should be as widespread as possible, and that every opportunity should be given to all to share in it, the highest amount which any one person may subscribe be limited to two guineas, but that any smaller sums will be gladly received."

A committee was then appointed to carry out the object of the foregoing resolutions.

The number of visitors to the Exhibition for the week ending July 17th, was 153,159; making a total since the opening of 1,803,407.

TANNING IN CHINA.

Consul Shepard, of Hankow, says that the method of tanning pursued in his consular district is not dissimilar in its earlier stages from that pursued in the United States. A vat is prepared—generally sunk in the ground—capable of holding about thirty hides. These are covered and left to soak in a solution of lime, called by the natives, "milk of lime." They are kept in this bath sixteen days and upwards, according to the season, cold weather requiring more lime than warm. The hair is then loosened, and the hides are taken singly, spread upon a bench, and thoroughly put through a scraping process to remove the hair and offal from the flesh. The tool used for this purpose is of peculiar construction. It is shaped like the capital letter H, one side being a steel or iron blade, and the other the handle, the cross-bar merely connecting them. The blade is about a foot in length, and the handle two or three inches less. The workman places the handle against his breast for greater ease and power, and with this forcible application of the tool to the hide the hair is speedily removed. The hide is then turned with the flesh side up, and by a similar manipulation all offal is removed, and the hide is reduced to a uniform thickness. A thorough washing follows, and the skin is cleansed of all remains of the lime. The refuse hair is saved for agricultural purposes, and the scrapings of the flesh side are boiled down for glue. After the cleansing, the hides are subjected to a vigorous rubbing with a heavy sandstone, or similar article, until both sides are thoroughly smooth. When this process is completed, a strong decoction of nutgall is sprinkled over the green leather, and then the tanning is commenced. The nutgalls are boiled in water over a slow fire until they become liquefied, and the strained liquor furnishes all the tannin used. Nutgalls are abundant in the districts furnishing exports to Hankow, and considerable quantities are sent to the United States. The next process to which the skins are subjected is as follows. A kind of furnace is built underground with an opening in circular form, from which a dense smoke issues when the fuel is fired. The fuel required is either wheat straw or a species of grass gathered from the mountain side; it is believed that nothing else will answer the required purpose. For the space of seven days the hides are passed backwards and forwards through the smoke issuing from the furnace, and unless it is to be blacked, the tanning of the leather is thus completed. If it is to be blacked, a liquor of vinegar in which iron has been left to corrode, or a solution of nutgalls and copperas, is ordinarily used, but at times simple lampblack is employed. The yellow-brown colour given to the leather by the smoking process is considered to be of remarkable beauty, and is therefore greatly preferred by manufacturers and wearers. The leather is made soft by sprinkling it with saltpetre during the smoking, accompanied by repeated and violent kneading of it, drying it in the air, instead of by exposure to the sun. The strength of the solution of saltpetre as applied is said to be kept secret, no apprentice being initiated to the knowledge of it until he has served for three years.

MEETINGS FOR THE ENSUING WEEK.

The following are Conferences for the week ending July 31st, at the Colonial and Indian Exhibition:—

MONDAY, JULY 26...Conference of the National Fish Culture Association, 10½ a.m. to 1 p.m.; 2 p.m. to 5 p.m.; 8 p.m. to 10 p.m.

TUESDAY, JULY 27...Mr. J. S. Jeans, "Railway Extension in the Colonies." 4 p.m. Rev. W. G. Green, "The Alps of New Zealand." (With Lime-light illustrations.) 8½ p.m.

WEDNESDAY, JULY 28...Mr. J. R. Mosse, "System of Crown Colonisation." 4 p.m. Mr. Stephen Bourne, "Colonial Tariffs." 8 p.m.

THURSDAY, JULY 29...Captain Everill, "The Future of New Guinea." 4 p.m. Mr. J. H. Hubbard, "Wild Animals and Game-Birds of the Canadian North-West." 8 p.m. Illustrated with specimens.

FRIDAY, JULY 30...Mr. F. W. Pennefather, "New Zealand, Historically and Socially." 4 p.m. Dr. B. W. Richardson, "Colonial Food and Fruit Supply." 8 p.m.

SATURDAY, JULY 31...Conference of the British Bee-keepers' Association. 4 p.m. Mr. Vincent Robinson, "Indian Carpets." 8 p.m.

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FRIDAY, JULY 30, 1886.

All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

Proceedings of the Society.

CANTOR LECTURES.

PETROLEUM AND ITS PRODUCTS.

By Boverton Redwood, F.I.C., F.C.S.

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Lecture IV.—Delivered March 29th, 1886.

(Continued from p. 913.)

Petroleum and paraffin oils of comparatively low specific gravity and flashing point burn more freely in most lamps, and cause less charring of the wick; but it is essential that the volatilising point of the oil should be such that vapour is not generated in sufficient quantity to cause its emission through the wick tube, and that the inflaming point should not be so low as to render the oil liable to take fire in the event of its being spilled. A lengthened experience has demonstrated that the present legal standard of flashing point is not only high enough, but provides a good margin, since the oil safely used throughout Germany and other Continental countries has, allowing for difference in the results furnished by the testing instruments, a flashing point about 6° Fahr. below that specified by law in this country.

In the course of the inquiry, Dr. Kellner suggested the desirability of constructing the lamp in such a manner that flame could not pass to the contents of the oil reservoir, and upon consideration it appeared to me that the desired object could be best attained by enclosing the wicks in a cylinder of wire gauze similar to that which is used in the construction of miners' safety lamps. With the concurrence of Sir Frederick Abel, I submitted this idea to Messrs. James Hinks and Son, and this firm have now arranged to fit their "Duplex" lamps with the "safety cylinder." Experiments which have been made demonstrate that if the small quantity of inflammable mixture of petroleum vapour and air contained in the cylinder is ignited, flame is not communicated to the similar mixture in the upper part of the oil reservoir, and it is therefore impossible for the oil reservoir to be fractured by an explosion. In the Defries lamp the long wick tube, which is always sealed by the oil, since the tube is longer than the wick, answers the same purpose.*

The amount of light which is obtained in the combustion of a given quantity of oil is by no means the same with all lamps, Argand burners being, as a rule—to which I have met with very few exceptions—more economical than flat-wick burners. Thus the mimimum consumption of oil per candle-light per hour in the case of flat-wick burners is now about 50 grs., as compared with about 41 grs. in the case of Argand burners. As a result of an extended series of photometric experiments made in 1879, with the assistance of my brother, Mr. T. Horne Redwood, I found that with the principal forms of mineral oil lamps then in use, the consumption, with only one or two exceptions, ranged from about 45 grs. to about 65 grs. per candle-light per hour; while more recent experiments, made with the assistance of my brother, Mr. Robert Redwood, exhibit, with the lamps now employed, a range of about 41 grs.† to over 70 grs. The results, however, depend to some extent upon the character of the oil, and the two sets of experiments are not strictly comparable.

The permanence of the flame, or, in other words, the extent of diminution in the luminosity of the flame during the use of the lamp, is a point of no small importance. The diminution may be caused by the use of an inferior wick, or of an oil reservoir of insufficient diameter, or by the bad quality of the oil, but the result also depends in no small degree upon the construction of the burner. With all burners, however, it is essential to employ an oil which does not cause excessive charring of the wick; a wick which possesses sufficient capillary attraction to raise the requisite quantity of oil to the flame; and a reservoir of such shape and diameter that the oil level does not become unduly depressed.

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* The lamp patented by Martin Rae in 1861 was, in this respect, somewhat similarly constructed.

† In the case of the Defries lamp.

At this point it will be convenient to consider the relative economy of lighting with mineral oil and with coal-gas.

Coal-gas may be fairly assumed to yield, under the average conditions of its ordinary domestic consumption, not more than the light of 2·6 standard candles per foot, or 2,600 candle-hours per 1,000 cubic feet. Taking the average consumption of mineral oil of specific gravity ·800, at 50 grs. per candle-light per hour, the cost of 2,600 candle-hours, if the oil were purchased at 8d. per gallon, would be 1s. 6½d. Therefore, at the present average prices of mineral oil and gas, the former illuminant is not much more than half the price of the latter. Mineral oil lamps are, as I have said, made which consume as little as about 41 grs. of oil per candle-light per hour; but, on the other hand, various improved forms of gas-burners, such as those of the inverted Argand type, give very much more light than 2·6 standard candles per foot, even without the use of the reflector which is generally fitted to them. Neither the oil lamps nor the gas lamps in question can, however, be taken as representing the average conditions under which the two kinds of illuminants are as yet most largely employed by the general public.

In the Defries lamp, the Silber lamp, and some others, oils of the "mineral colza," or "mineral sperm," or "pyronaphtha," or "solar" class, which are of comparatively high specific gravity and low volatility, burn well.

The following suggestions relating to the construction and use of mineral oil lamps have been drawn up by Sir Frederick Abel and myself, on the basis of the results obtained in the experimental inquiry already referred to:—

1. The passage of flame from the burner of the lamp to the interior of the oil reservoir should be prevented by protecting all channels of communication with wire gauze of twenty-eight meshes to the inch, of the kind used for safety-lamps, or by enclosing the wick beneath the burner in a cylinder closed at the bottom and constructed of wire gauze of the kind specified above, or in a tube of thin sheet metal.

2. It is preferable that the oil reservoir of the lamp should be of metal, and it should not have any opening or feeding place other than that provided by taking out the burner.

3. The wick should be of soft texture, and not tightly plaited. It should fill the entire space of the wick tube, but should not be compressed within the latter.

4. A fresh wick should always be thoroughly dried in front of the fire before being placed in the lamp; it should not be much longer than sufficient to reach the bottom of the reservoir. Where the construction of the lamp admits of it, the wick or wicks should be thoroughly saturated with the oil before the burner is placed in the collar, by passing half the length through the burner and dipping the upper half into the oil reservoir.

5. The oil reservoir should always be nearly filled before the lamp is lighted; if any oil is accidentally spilled upon the outside of the reservoir, the latter should be wiped thoroughly clean before the lamp is lighted.

6. The wick should, after lighting, be at once lowered, and afterwards gradually raised as soon as the burner and chimney have become warm. With most forms of mineral oil lamps the flame cannot be much lowered without the production of a disagreeable odour of unconsumed petroleum.*

7. Mineral oil lamps, which are unprovided with extinguishing apparatus, should be extinguished as follows:—The wick is lowered until there is only a small flickering flame; the mouth is then brought to a level with the top of the chimney, and a sharp puff of breath is directed across the opening.

8. No lamp will burn well unless proper care is taken that the openings for the admission of air are unobstructed by dirt or charred wick.

9. Cans or bottles used for the oil should be carefully kept free from water and dirt, and thoroughly closed.

A memorandum embodying these suggestions has been issued by the Metropolitan Board of Works.

I may here call attention to Forrest's ingenious measuring apparatus, for use in the retail sale of petroleum oil, a specimen of which has been kindly lent me by Mr. H. J. Chaney, of the Standards Department of the Board of Trade.

The use of petroleum or paraffin oil for domestic illumination having thus received full consideration, I must say a few words on the employment of these oils for the warming of dwelling-houses and conservatories, and for cooking purposes. We have before us a selection of mineral oil stoves and cooking apparatus, for which I am indebted to the Albion Lamp Company, and to Messrs. Wright and Butler. The lamps with which these stoves are usually fitted differ chiefly from those which have already been described, in being provided with a metallic chimney, but considerable ingenuity is in some instances exhibited in the constructional arrangements for utilising and distributing the heat, and at the same time producing odourless combustion. The Albion Lamp Company, who are the sole manufacturers of the mineral oil stoves for cooking, warming, and lighting patented by Mr. E. A. Rippingille, claim to have introduced the square form of stove in place of the cylindrical form previously adopted. They also claim to have been the first to construct the sliding oil tank, and to substitute for use with large wicks stamped metal cones of uniformly accurate shape and size for the cast-iron cones, which being finished by filing, varied in dimensions. This company manufacture combination oven stoves, in which the flame provides heat for simultaneous boiling and baking; and have provided their stoves with circulating draught arrangements, whereby the attainment of a satisfactory bottom heat in the oven body is stated to be insured.

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* In the Defries lamp the flame may be a good deal reduced in size without this result accruing.

The Snessoreff mineral oil stove differs from those already referred to in being chimneyless. This stove burns satisfactorily, and possesses the advantage that cooking utensils can be placed closer to the flame than is the case where a chimney is employed.

I have recently received from Messrs. Meissner, Ackermann, and Co., a domestic cooking stove, in which, as you see, the fuel (ordinary petroleum oil) is burned from a jet without a wick. The oil is first poured into the lower reservoir, and is thence pumped into the upper reservoir, under some pressure. The pipe leading from this upper reservoir is coiled into a circular form, and beneath it a little methylated spirit is first burned. When the pipe has thus been throughly heated, a tap is turned and the oil passes from the reservoir to the jet, where it is ignited, the heat of the burning oil maintaining the required temperature of the coil.

Passing now from the consideration of the use of mineral oils for domestic lighting and heating, I must say a few words in regard to the use of those oils on ship-board, and on railroads. The burners employed for these purposes have not any characteristic to which I need refer, but specially constructed lanterns are necessary to protect the flame from wind and rain. The principles of some of the arrangements adopted have been described by Mr. Silber, in a paper read before the Royal United Service Institution, in 1878. The lantern may be compared to a room so small that the currents of air entering it would have neither time nor space to lose velocity and pressure, but would strike the flame in a forcible manner, and accordingly it is necessary to provide circuitous channels for the entrance of the air and escape of the products of combustion, these channels being so constructed that the impact of the strongest wind to which the lantern is liable to be subjected will not diminish or increase the speed or quantity of the air supply, or check the escape of the products of combustion, or allow the entrance of rain or sea-spray. The problem is by no means a simple one, but it has been successfully solved by several inventors. In the original forms of the Silber lanterns, the burner was of the chimneyless type, and the entrance of air was controlled by the use of vertical tubes and wire gauze, while to provide for the escape two kinds of tops were used. One of these tops was intended for cases where the lamp was exposed to a current of air mainly horizontal; and the other when the lamp was, as on board ship, liable to receive a vertical pressure of air driven downwards, for instance, when a wave falls upon it. Both tops were provided with an inverted cone placed at a little distance above an inverted funnel, the exit of the heated air being thus provided for, while at the same time the inrush of wind was prevented. Mr. Silber has since relinquished the use of the chimneyless burner for railway "head," "tail," and "side-lights," and now adopts a wholly different form of lantern, in which there is a system of wind-guards so arranged that the entering air currents are thrown from one surface to another, until they have lost their original velocity. It is upon the latter principle that such lanterns as we are now considering are generally constructed, though there are variations in points of detail between the lamps of different manufacturers. The Silber railway-lamp exhibited has a combined metal chimney and reflector. In the railway engine head-light, train side lights, and ship's mast-head light, which Messrs. J. Defries and Sons have been good enough to send, an Argand lamp with glass chimney is used. Considerable difficulty appears to have been experienced in the construction of a hand signal lantern for mineral oils which is not liable to be extinguished. The flame produced in the burning of such oil leaves the wick far more easily than a colza oil flame does, and although there are many hand lanterns which can be violently swung without disturbing the flame, few will stand a sudden jerk, produced by lowering the hand in which the lantern is held and then quickly raising it, such as might easily occur if the guard or signalman stumbled.

I have recently travelled in a train on the Great Northern Railway which is experimentally lighted with petroleum oil burned in the Silber roof-lamps. These lamps are furnished with a wick projecting from the side of the annular oil reservoir, on the principle previously adopted in the Shallis and Thomas lamp of Messrs. Ridsdale and Co., and there is thus nothing below the flame to obstruct the passage of light through the glass dish which forms the bottom of the lantern. I found that a newspaper could be read with great ease in a carriage so lighted, and the lamps are stated to burn, with little diminution in illuminating power, for eighteen hours. Mr. Silber has been good enough to lend me one of these lamps, and you will observe that it is of simple construction. The wick can be raised or lowered by means of a key from the interior of the carriage or from the roof, and the lamp can be lighted without removing it from the lantern, by simply turning back the hinged top and opening a small door. I am indebted to Messrs. Ridsdale and Co. for specimens of the Shallis and Thomas roof-lamp to which I have referred, and of a railway signal lamp patented by Mr. T. C. J. Thomas.

The employment of mineral oils for lighthouse illumination is a branch of the subject to which we must next give our attention. Sir James Douglass, the engineer of the Trinity-house, states that, in 1861, experiments were made by the Trinity-house with samples of mineral oil, but the results were not found so satisfactory as to justify a change from colza oil, then generally used. In 1863, Mr. W. C. Wilkinson produced an efficient lighthouse burner for use with mineral oils, but owing to certain circumstances this burner was never practically tried. Mr. J. F. C. Farquhar formed the opinion that the use of metal cones and buttons was objectionable, as it led to the production of great heat in the burner, and, besides, obscured a portion of the flame; and he constructed a lighthouse burner in which the air was caused to impinge upon the flame by contracting the chimney in certain parts. In 1869, Captain Doty submitted to the Trinity-house a mineral oil burner for lighthouse purposes, but according to Sir James Douglass this burner was found to be considerably inferior to the colza oil burner then in use. Mr. Brunton explained in a paper read before the Institute of Civil Engineers that the inferiority only existed in the case of the four-wick burner, and that the defects which this burner at first possessed were remedied two years later. Meanwhile, Sir James Douglass, continuing his experiments, found that the Fresnel burner employed with colza oil could, by a very simple alteration, be rendered suitable for use with mineral oil. It is well known that the colza oil is supplied to the lighthouse burner by means of a pump, the oil being thus caused to continuously overflow the wick-tube, as in the case of the "Moderator" lamp. Sir James Douglass found that, by simply providing for the overflow of the mineral oil at a considerably lower level, and therefore at some distance from the top of the wick or wicks, the same burners and appliances could be satisfactorily used for such oil. The amount of light obtained from a flame of given size was afterwards very much increased by the adoption of the burner patented by Sir James Douglass in 1881. The invention is described in the specification as consisting "in an arrangement of an outer deflector surrounding the burner and lower part of the flames,* one or more of which it covers, and in connection with this deflector is a deflecting glass chimney, both deflector and chimney being so formed as to force the outer flames on to the inner flame or flames, and thus to condense all the flames,† and deflect on to the internal and external surfaces of each of the flames the whole of the ascending currents of air, and in such a manner as to invigorate the combustion of the flames and augment the intensity of their light." The invention also "includes the means of employing one or more rings of flame with perfect combustion, and thus decreasing or increasing the intensity of the light without any alteration in the external form or dimensions." The deflector referred to consists of a triple cone so formed as to direct the air upon the flame at three different heights.

According to Mr. Brunton, the results yielded by the Doty burner with paraffin oil thus compare with those previously obtained with colza oil ‡:—

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* In the larger lighthouse burners as many as nine concentric wicks are employed.

† Where lenses are employed, it is important to have the flame as much condensed as possible.

‡ Mr. Brunton subsequently stated that in experimenting with the Doty burner he had, by a modification of the chimney and a slight alteration in the size of the disc, succeeded in obtaining, from a burner which had previously given a light not exceeding 25 candles, a light of about 39 candles.

ILLUMINATING POWER IN STANDARD CANDLES.

	Four wicks.	Two wicks.	Argand burner.
Lighthouse burner with colza oil	270	58	14
Doty burner with paraffin oil..	288	84	20

Equivalent of sperm to one gallon of oil.

	Four wicks.	Two wicks.	Argand burner.
Lighthouse burner with colza oil	21½	17½	14½
Doty burner with paraffin oil..	27½	27	27

The following average results are said to have been obtained with Mr. Farquhar's burners:—

	Six wicks.	Four wicks.	Two wicks.
	Candles.	Candles.	Candles.
Burning colza oil	750	334	90
Burning paraffin oil	700	306	85

From Sir James Douglass's burners the following results have been obtained:—

Illuminating Power.

	Six wicks.	Four wicks.	Two wicks.	Argand.
	Candles.	Candles.	Candles.	Candles.
Burning colza oil .	722	328	82	23
Burning paraffin oil	730	330	80	25

Equivalent of sperm to one gallon of oil.

	Six wicks.	Four wicks.	Two wicks.	Argand.
	lbs.	lbs.	lbs.	lbs.
Burning colza oil .	26·76	28·10	25·77	28·00
Burning paraffin oil	24·98	26·94	27·43	28·57

The subjoined comparative statement is founded upon Sir James Douglass's earlier results:—

	Colza.	Paraffin.
Maximum intensity of light produced	110 0	85·5
Minimum intensity at end of 16 hours' burning	81·8	66·9
Per-centage of falling off	18·2	21·9
Consumption of oil per lamp for 16 hours, in fluid ounces	42·1	34·0
Relative quantity of light produced per gallon of oil consumed	100·0	103·0

In the discussion which followed the reading of the paper referred to, Mr. W. H. Deering stated that lighthouse paraffin oil, containing about 85 per cent. of carbon and 15 per cent. of hydrogen, should be more efficient as an illuminant than colza oil containing about 77 per cent. of carbon, 12 per cent of hydrogen, and 11 per cent. of oxygen; the latter oil, from its oxygen content being necessarily regarded as a body already partly burnt. But these per-centages were, he pointed out, per-centages by weight, while the relative quantity of light was referred to a unit of volume, one gallon, without taking into account the difference in specific gravity of the two oils. The specific gravity of colza oil is about ·916, and that of lighthouse paraffin oil about ·815. Taking the statement of the results obtained by Sir James Douglass, one gallon of colza oil, weighing 9.16 lbs., gave 100 units of light, while one gallon of lighthouse paraffin oil, weighing only 8·15 lbs., gave 103 units of light. Calculating this to 9·16 lbs. for equal weight: from colza oil 100 units, and from the paraffin oil 116 units light were obtained. In subsequent correspondence upon the subject of Mr. Brunton's paper, Sir James Douglass gave the following statement, showing the average comparative efficiency of colza and mineral oils (paraffin and petroleum) of good quality, when consumed in Trinity Lighthouse lamps, and burning for sixteen hours without any trimming of the wicks:—

	Colza oil.	Mineral oils.
1. Mean intensity of light for 16 hours	100	88·8
2. Decrease in intensity after 16 hours' burning, per cent.	1·75	10 75
3. Quantity of light produced per gallon of oil, expressed in standard sperm candles (or English units), consuming 120 grains of sperm per hour	1,600	1,778
4. Quantity of light produced per gallon of oil, expressed in pounds of sperm......	27·4	30·4
5. Quantity of light produced per gallon of oil, expressed in cubic feet of 16-candle London gas, consumed in a burner giving 4 candles per cubic foot of gas	400	444
6. Relative quantity of light produced per gallon of oil consumed	100	111·1
7. Relative efficiency of colza and mineral oils for lighthouse burners (mean of columns 1, 2, and 6)......	100	90·9

Commenting upon these results, Sir James Douglass pointed out "that the chief defect in mineral oils for lighthouse illumination was the decrease in the intensity of the light towards the latter part of a long winter's night. This was due to impurities in the oil causing rapid destruction of the cotton wicks, and it was a matter requiring special attention of refiners of petroleum and paraffin. That it was possible to produce the quality of oil for the purpose he had abundant evidence, having experimented with samples of American petroleum, with which there had been no appreciable decrease in the intensity of the light at the end of 16 hours' burning of the lamp. The question would therefore appear to be one of increased care in the manufacture, and consequently a small addition to the cost of the article." The Trinity-house contract conditions specify that—

1. The mineral oil required to be supplied under this contract is to be of the best possible quality, the greatest care is to be taken in its preparation, and it must be perfectly free from sulphuric acid.

2. In all cases, whether the oil be petroleum or paraffin, the flashing point is to be determined by using the apparatus described in Schedule 1 of the Petroleum Act of 1879.

3. If the oil be petroleum, its flashing point is to be not lower than 125° Fahrenheit (close test), and it is to distil between 302° and 572° Fahrenheit, the temperature of the vapour, not that of the liquid, being taken.

4. If the oil be paraffin, its specific gravity is to be not less than 0·810, nor greater than 0·820, at 60° Fahrenheit; its flashing point is to be not lower than 140° Fahrenheit (close test), and it is to distil between 302° and 572° Fahrenheit, the temperature of the vapour, not that of the liquid, being taken.

5. The illuminating power of the oil supplied, whether petroleum or paraffin, is to be equal to that of the best colza oil, when consumed in a Trinity-house Argand lamp.

Hitherto the only mineral oil tendered which has complied with these requirements is a specially made shale oil.

The specifications issued by the United States Lighthouse establishment in November, 1881, provide that the mineral oil shall have a specific gravity "not less than ·802," a flashing point of not less than 140° Fahr. and a fire test of not less than 154° Fahr., the two latter tests being made with Tagliabue's instrument. The oil is to remain limpid at zero; and "litmus paper immersed in it for five hours must remain unchanged." The oil is to be photometrically tested in a fifth-order Hains lamp, and the light is to be equal to that of eighteen sperm candles, and to continue undiminished during five hours' burning.

In August last year a report was presented of an elaborate series of experiments conducted by a special committee of the members of the Corporation of Trinity-house, with the object of determining the relative merits of electricity, gas, and oil as illuminants for lighthouses. The report concludes with the expression of the opinion:—"That for the ordinary necessities of lighthouse illumination mineral oil is the most suitable and economical illuminant, and that for salient headlands, important landfalls, and places where a very powerful light is required, electricity offers the greatest advantages."

Sir James Douglass has been good enough to lend me the series of beautiful specimens of lighthouse burners, with models of the flames produced, which are on the table, and has also supplied me with valuable information on the subject of the use of mineral oils in lighthouse lamps.

For the lighting of large spaces out of doors, or in covered yards, arrangements for burning mineral oils in the form of spray have been devised. In the so-called "Lucigen" (Lyle's and Hannay's patents), which is now being employed in bridge building and similar work, the spraying is produced by the employment of compressed air. This apparatus is stated to give a light of 2,000 candle-power at a cost of about 2d. per hour, the oil used being creosote, or other heavy mineral oil.

I have already alluded to one of the earliest forms of mineral spirit lamps, that of Read Holiday, as still being employed for open air illumination.

Petroleum spirit, or "benzoline," is still largely used as an illuminant for domestic purposes, and is burned with a cylindrical wick in small chimneyless lamps, the reservoir of which is filled with sponge, or other absorbent material. The lamp should contain only as much of the spirit as is taken up by the material, and there is thus no danger of spilling in the event of the lamp being dropped. Indeed, the only danger connected with the use of these lamps is that which attends the filling of the lamp with so volatile and inflammable a liquid. An interesting, historical collection of these "sponge lamps" has been lent me by Mr. Léon Clerc. I have in my possession a benzoline lamp which bears the date of 1855. In some cases the spirit lamp is so constructed as to volatilise the spirit, the vapour being thus burned at a jet. Wood's "gas-maker" lamp is of this type. This method of combustion is largely adopted in the use of petroleum spirit for street lighting. One form of lamp designed for this purpose has been furnished by Messrs. Hearson and

Co., and is now before you. The spirit reservoir is on the top of the lantern, and in the horizontal tube, termed a retort, which is within the lantern, the liquid is volatilised, the vapour being consumed at a steatite burner. Lamps have also been constructed for use with the still more volatile "gasoline," on the principle of saturating fragments of some absorbent material, placed in a reservoir, with the spirit, and allowing the vapour to descend by gravity through a tube, to an Argand burner, at which it is lighted; a steady flame of considerable luminosity being thus produced.

The various "air-gas" machines are mechanical arrangements for saturating atmospheric air with the vapour of gasoline. These machines are used to a considerable extent in lighting country houses in the United States and elsewhere. The more volatile petroleum, coal, and shale products have also been employed for "carburetting" coal-gas. The carburetting of illuminating gas or air was first proposed in general terms, in 1832, by Lowe, and in 1841 a process for effecting it was patented by him. Mansfield and Longbottom also worked at the subject before the introduction of petroleum products rendered the operation commercially unsuccessful. The various air-gas machines are constructed on the principle of passing air over a considerable surface of gasoline, in some cases curtains of flannel, suspended in the carburetting chamber so that their lower edges dip into a reservoir of the fluid, being employed. Müller's "Alpha" gas-making machine consists of a rectangular "carburettor," or chamber, containing a number of shallow trays, over which gasoline is caused to flow. In connection with the carburettor is a revolving blower driven by a weight, a weighted lever being added to keep the drum revolving while the cord which sustains the weight is being re-wound on the drum. The air is driven by the blower over the surface of the gasoline in the trays, and is thus carburetted. Müller's gas generator for gas-engines has a similar carburettor, but the gas being required to be supplied under greater pressure for such purpose, an air-pump, driven by the gas-engine, is employed to force the air through the carburettor. In this apparatus a small lift-pump, also driven by the gas engine, is used to keep the trays supplied with gasoline. Both machines were exhibited at the International Health Exhibition. The chief difficulties experienced in the use of air-gas machines arise from over-saturation of the air in warm weather, or when the apparatus is first charged, and reduction in the temperature of the hydrocarbons caused by evaporation. These difficulties have been to a great extent overcome by immersing the carburetting chamber in a tank of water, and placing the whole apparatus below ground. Even under these circumstances there is, however, a fractional evaporation, and a residue of insufficiently volatile spirit remains after the apparatus has been for some time in use. With a view of overcoming this objection to the process, an apparatus, termed a "metrical carburettor," has been introduced. This machine is so constructed that a measured quantity of the gasoline is delivered to the gas or air passing through it, the proportion recommended being one and a half to two gallons per 1,000 cubic feet in the case of gas, and three to six gallons per 1,000 cubic feet (according to the illuminating power required) in the case of air. Dr. Letheby stated in 1861 that the carburetting of coal gas with ten grains of volatile hydrocarbon per cubic foot resulted in an economy of from 40 to 50 per cent. Air charged with 735 grs. of gasoline per cubic foot has been found to have an illuminating power of 16½ standard candles, when burned at the rate of 3½ cubic feet per hour in a 15-hole Argand burner; equal to 23·7 candles per 5 cubic feet an hour.

Mineral oils are also used to a considerable extent as a source of gas for lighting purposes. On allowing the oil to pass slowly into a heated retort, dissociation of the hydrocarbons occurs, and a permanent gas of high illuminating power and very suitable for compression, is produced. The process is employed at gas-works in the United States and in Russia for the enriching of coal-gas. In Pintsch's system of railway-carriage lighting, mineral oil gas, produced as described, is used; and the gas is also very successfully applied in the lighting of buoys and the smaller lighthouses. The gas is pumped into the buoys under considerable pressure, and thus a supply of gas that will maintain a flame for a great length of time is easily provided. Sir James Douglass informs me that at some of the smaller light-stations it has been found practicable to employ a clock-work arrangement to automatically turn the gas on and off at fixed hours, the time being adjusted to correspond with the hours of darkness. Thus a light may be displayed without the necessity for personal attention at more frequent intervals than a week or more, which is of great advantage where the station is difficult of access. At the lighthouse at Langness, in the Isle of Man, and on the Ailsa Craig rock, the Commissioners of Northern Lights are using mineral oil gas manufactured in James Keith's patented plant, a model of which was shown at the International Health Exhibition. At the former lighthouse, however, the gas is, I believe, only used for the gas-engine which works the fog-horn. Pintsch's and Keith's systems of manufacture have been fully described by Dr. Armstrong, in the *Journal of the Society of Chemical Industry*. In the use of Pintsch's apparatus, 80 cubic feet of gas per gallon of oil is stated to be a good yield, but Mr. Keith asserts that he obtains from 100 to 150 cubic feet of 50-candle gas per gallon. The Metropolitan Gas Company, of New York, calculate upon getting 70 cubic feet of 60-candle gas per gallon. In America oil-gas is not only used for enriching coal-gas, but is also supplied diluted with water-gas; much of the gas burned in New York being a mixture of oil-gas and water-gas.

We have now to consider the subject of the employment of petroleum and its products as fuel. This application of mineral oils has, within the past few years, received renewed attention, and is of rapidly increasing importance. The experiments conducted by Lavoisier and Laplace, about the year 1780, and by Count Rumford, in 1814, supplemented by the more exact determinations made by Crawford, Dalton, Desormes, Despretz, and Dulong, and by the subsequent researches of Favre and Silbermann and of Andrews, have furnished us with tolerably accurate data as to the amount of heat generated by the combustion of various substances. The quantities of heat generated by the combustion in oxygen of one gramme of hydrogen and of carbon are stated in the following Table, the unit employed being the quantity of heat which is required to raise the temperature of one gramme of water from 0° to 1° Centigrade :—

Hydrogen	33881	Andrews.
	34462	Favre & Silbermann.
Carbon (product CO_2), wood charcoal......	7900	Andrews.
	8080	Favre & Silbermann.

The per-centage composition of a fuel having been ascertained by analysis, its calorific power can, therefore, be determined by calculation. Thus, in the case of a fuel consisting only of carbon and hydrogen, if we multiply the amount of carbon and the amount of hydrogen by the respective numbers expressing the calorific power of carbon and of hydrogen, and add the products, the sum represents the relative calorific power of the fuel. When oxygen is present in the fuel a deduction has to be made, and if we assume that it is the hydrogen which is rendered ineffective by combination with the oxygen, then, as in water, the oxygen is combined with one-eighth of its weight of hydrogen, we have to deduct from the hydrogen of the fuel one-eighth of its weight of oxygen.

The British unit of heat is the quantity which raises the temperature of 1 lb. of water 1° Fahr. (from 40° to 41° Fahr.), but, as Professor W. J. Macquorn Rankine pointed out in an instructive paper on "The Economy of Fuel," read before the Royal United Service Institution in 1867, the most convenient unit for practical use in relation to the value of fuel is the unit of evaporation, that is the heat required to evaporate a unit of weight of water under the mean atmospheric pressure of 14·7 lbs. per square inch, the water being supplied to the boiler at a temperature of 212° Fahr. The British unit of evaporation is the quantity of heat that evaporates 1 lb. avoirdupois of water at 212° Fahr., but the evaporative power is usually determined at a temperature above 212°, and with the feed-water at a temperature below 212°, the necessary corrections being made.

Calculated on the basis of the figures of Favre and Silbermann already given, the evaporation unit for hydrogen is 62·658, and for carbon 14·691.

In 1869, H. St. Claire Deville, being instructed by the French Government to conduct a series of experiments with the object of ascertaining the value of liquid fuel, determined the calorific effect of various samples of crude petroleum from the United States and other countries. In the case of a sample from Oil Creek, United States, he found the total calorific power to be 9,963 Centigrade units, equal to an evaporation of 16·17 lbs. of water per 1 lb. of oil; but his actually obtained yield of steam was 14·05 lbs. per 1 lb., 1,252 heat units out of the 9,963, by exact measurement, being lost in operating the chimney to produce draught, and 76 units by radiation. A sample from Franklin, United States, of higher density, gave 10,672 units; and a third sample of Ohio oil, dense and black, 10,399. In 1871, Deville determined the heating power of various samples of Russian petroleum of the following composition :—

	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.
Hydrogen	12·5	11·7	12·0	13·6	12·3
Carbon	87·4	87·1	86·5	86·3	86·6
Oxygen	0·1	1·2	1·5	0·1	1·1
	100·0	100 0	100·0	100·0	100·0
Sp. gr. at 0° C.	·882	·928	·897	·884	·938

On the basis of calculating the heat of combustion from the composition of the oil by subtracting from the hydrogen one-eighth of the oxygen, multiplying the difference by 344·62, and adding to the product the quantity of carbon, multiplied by 80·8, Deville accordingly gave the theoretical heat of combustion of the five samples as follows:—No. 1, 11,370 cal.; No. 2, 11,000 cal.; No. 3, 11,060 cal.; No. 4, 11,666 cal.; and No. 5, 11,200 cal. The calorimeter employed in the subsequent experiments was a steam-engine of 8 horse-power, with a Belleville boiler, in which the pressure was kept constant within 1-10th atmosphere. By means of this engine, air was pumped into an iron reservoir, of 40 cubic inches capacity, provided with a stop-cock, through which the air escaped under a constant pressure of 2¾ atmospheres. In the case of samples 4 and 5, the actual results obtained were as follows:—

	Found.		Calculated.		Difference.
No. 4......	11,460	..	11,660	..	200
„ 5......	10,800	..	11,200	..	400

Assuming the mean difference to be thus 300 heat units, the other samples would give:—

	Found.		Calculated.
No. 1..........	11,070	..	11,370
„ 2..........	10,700	..	11,000
„ 3..........	10,760	..	11,060

The whole of these results, obtained with Baku oils, were higher than those yielded by the American petroleums previously examined by Deville.

In a paper read in this room in 1868, Dr. Paul explained at some length the theory of the combustion of fuel, and pointed out the causes of the large differences between the total evaporative power of a fuel and the results obtained in practice. The conclusions ably expressed in this paper were to the effect that, after making the necessary deductions from the theoretical evaporative power, the effective heat amounted to 15·8 units in the case of a hydrocarbon containing 14 per cent. of hydrogen, the proportion of hydrogen in petroleum being about 13 per cent. This estimate would make the relative evaporative efficacy of petroleum, as compared with coal, as about 1 : 1·39, but in the calculation an allowance is made for the use of double the necessary quantity of air, and if the hydrocarbon be burnt with only just enough air for combustion, the effect capable of being realised would be 13 to 14 per cent. greater.

The following Table was given by M. Goulishambaroff, in an article "Sur les propriétés Physiques et le Pouvoir Calorifique des Petroles et des Huiles Minérales" (*Comptes Rendus*, lxix, 442-453):—

CRUDE PETROLEUM OIL.

	PENNSYLVANIAN.	RUSSIAN.		
		Light.	Heavy.	Naphtha refuse.
	per cent.	per cent.	per cent.	per cent.
Carbon	84·9	86·3	86·6	87·1
Hydrogen........................	13 7	13·6	12·3	11·7
Oxygen	1·4	0·1	1·1	1·2
	100·0	100·0	100·0	100·0
Sp. gr. at 0° C.................	·886	·884	·938	·928
Heating power, British thermal units	19,210	22,628	19,440	19,260
Theoretical evaporation at 8 atm. pressure, in lbs. of water per lb. of fuel	16·2	17·4	16·4	16·2

The difference between the theoretical and the practical evaporative powers of fuels arises from abstraction of heat rendered latent; from imperfect combustion resulting from the use of too little air; from loss of heat by conduction and radiation, as well as cooling produced by the admission of too much air; and from loss of the heat which escapes with the furnace gases. In the use of liquid fuel there is less difficulty in insuring perfect combustion than in the use of coal, and, accordingly, the practical results obtained when liquid fuel is properly employed compare more favourably with those yielded by coal, than would be anticipated from a consideration of the relative theoretical results.

A great number of arrangements for burning liquid fuel have been patented, in some instances an absorbent material being employed as a kind of wick, but the method which has been commonly adopted with the greatest success consists in spraying or pulverising the oil by a jet of steam, either wet or superheated. The mechanical action of the steam jet results in a thorough mixing of the vaporous fuel with the air necessary for its combustion; and Professor Rankine conceives that there is besides, a chemical action, the oxygen of the steam combining to some extent with the carbon of the fuel, the hydrogen of both being set free, and the deposit of unconsumed carbon, which is otherwise liable to occur in the use of petroleum as a liquid fuel, being prevented. Professor Rankine strongly recommends the superheating of the steam employed. Even better results, however, than those which have been obtained by the spraying process, have been yielded in the use of Mr. Ludwig Nobel's "trough burners," to which I shall have occasion to refer later.

As long ago as 1830 Pinkus advocated the use of hydrocarbons for steam generating purposes; but the first successful practical trials of liquid fuel in this country were, I believe, those made at Woolwich Dockyard, in 1864, with Richardson's apparatus. Various oils were used in these experiments, and an evaporation of 12 to 13 lbs. of water per lb. of oil, as compared with 7·3 lbs. per lb. of coal, was obtained. The arrangement adopted by Bridges Adams for burning liquid fuel was also tried at Woolwich about the same time, and in 1868 the Government authorised the experimental application to a yacht boiler of the system invented by Wise, Field, and Aydon some years previously. In the same year Crow's oil-burning apparatus was tested by the Admiralty, and some successful trials of Dorsett's system were made on the *Retriever*, a steam ship of 500 tons burden. In the meantime, in 1862, patents for oil-burning apparatus had been granted in the United States, to Bidley, Shaw, Linton, and others. In 1865, Shpakovsky devised an arrangement for spraying liquid fuel by means of a blast of air, and a steamer was fitted with this apparatus in Russia in 1870.

In some of the more primitive refineries at Baku, I observed that the petroleum residuum, or "astatki," was used as fuel by burning it upon the hearth of the furnace, but the combustion is under such circumstances very imperfect, a large quantity of dense black smoke being evolved. At the better conducted refineries, such as that of the Nobel Company, the spray principle is adopted, the burner employed being either that of Lentz or some modification of it. The Lentz burner is fitted with two pipes, one conveying the liquid fuel and the other steam from the boiler. These pipes meet in the burner, which is so constructed that the oil trickling through notches in the edge of a diaphragm is blown off by steam which escapes at the under side in jets, with intervening spaces for the admission of air. The burner is fixed in front of the fire door, and the long horizontal flame produced is projected into the furnace. The "pulverisers" of Artemeff, of Brandt, of Nobel (which is a modification of Brandt's), and others, will be found fully described and illustrated in *Engineering*, vol. 35 (1883), by Mr. Thomas Urquhart, Locomotive Superintendent of the Griazi-Tsaritsin Railway of Southern Russia. The burner which is stated to have given the best results in use on the locomotives of that railway company, is Karapetoff's; and that which has been adopted by the Russian Government as best adapted for use in torpedo vessels is Kaufmann's. All these pulverisers depend for their action upon the principle illustrated in the description of the Lentz apparatus, and differ only from that burner in details of construction and in the shape of the flame produced. They are all, in fact, similar to the apparatus patented by Messrs. Wise, Field, and Aydon, in 1867, and used at the works of Messrs. J. C. and J. Field, of Lambeth. In a valuable paper, which will be found in the "Proceedings of the Institute of Mechanical Engineers" for 1884, Mr. Urquhart gives the results obtained in the practical use of petroleum residuum on the railway already referred to. Comparative trials, made in winter, showed that the economy of petroleum, as compared with anthracite, was 41 per cent. in weight and 55 per cent. in cost; and, as compared with bituminous coal, 49 per cent. in weight and 61 per cent. in cost. As compared with wood, petroleum was 50 per cent. cheaper. At a speed of 14 miles an hour up an incline of 1 in 125 the steam pressure was easily kept up at a pressure of 8 to 8½ atmospheres, with a No. 9 injector feeding the boiler continuously. In summer the mean evaporation per lb. of fuel was 11·35 lbs. of water from an initial temperature of about 55° Fahr., the theoretical evaporative power being 16·2. The useful effect was, therefore, 70 per cent. The comparative trials in summer gave a difference of 56 per cent. in weight and 66 per cent. in cost in favour of petroleum as compared with bituminous coal, and 52 per cent. in weight and 63 per cent. in cost as compared with anthracite. The results for the entire year gave for petroleum, as compared with the mixture of half bituminons and half anthracite coal used, an advantage of 38 per cent. in weight and 46 per cent. in cost in the case of the goods trains, and 25 per cent. in weight, and 33 per cent. in cost in the case of the passenger trains. Mr. Urquhart remarks that he has successfully used petroleum as an anti-incrustator, and also finds that the presence of oil in the boiler tends to reduce the tendency to priming, unless too much is employed. Petroleum is more difficult to use in a locomotive boiler than in a marine or stationary boiler, and at first it was found impossible to prevent leakage of tubes, accumulation of soot, and inequalities of heating of the fire-box; but by the use of properly arranged brickwork inside the fire-box these difficulties have been overcome. The weak point of all pulverising arrangements is the comparatively uneconomical use they make of the fuel, besides which the noise of the blast is in some instances objectionable, and the trough burner of Mr. Ludwig Nobel, with which no steam is used, has been found to give considerably better results. This apparatus consists of a series of shallow troughs (one of which I have on the table), so arranged one above another at the mouth of the furnace, that the burning oil flows by successive stages from the highest to the lowest. Comparative experiments made with this apparatus, with a spraying arrangement, and in the use of coal in the same boiler at Messrs. Nobel's works, gave the following results:—

PRACTICAL EVAPORATION OF WATER PER POUND OF FUEL.

Coal	7 to 8 lbs.
Petroleum residuum, sprayed ..	12 ,,
Petroleum residuum, burned with Nobel's system of troughs....	14½ ,,

The trough burner has also been very successfully employed in metallurgical operations.

Petroleum residuum is the only fuel employed for steam generating purposes in the steamships on the Caspian Sea, and I observed that, both in the case of these vessels and of the locomotives on the trans-Caucasian Railway, the combustion was smokeless, though occasionally a slight odour of imperfectly consumed oil was perceptible.

It is reported that the Central Pacific Railway Company have recently commenced the use of liquid fuel on their steam-ships, and have obtained results which show the cost of the oil to be 56 per cent. of that of the coal previously employed.

In this country experiments are now being made at Portsmouth with the object of determining the relative economy of liquid fuel and coal for use in the belligerent navy. At the end of last year the cargo steamer *Himalaya*, of 800 tons burden and 100 horse-power nominal, which had been fitted with Mr. Percy P. Tarbutt's oil-burning apparatus, made a successful trial trip to Leith and back, making 8½ knots per hour under disadvantageous circumstances, her mean speed when fired with coal having been 6½ to 7 knots. The boilers in this vessel have three furnaces, each of which is lined with fire-brick and provided with a fire-brick baffle, and a combustion chamber beyond. Within the chamber is a coil of pipe to superheat the steam used in spraying the oil. Messrs. Tarbutt and Quentin, the managers of Tarbutt's Liquid Fuel Company, inform me that experiments made by two engineers of the Compagnie Française des Diamants du Cap, at the works of Messrs. Oliver and Company, Chesterfield, with a Robey boiler fitted with the Tarbutt burner, showed a mean evaporation of 16·3 lbs. of water per lb. of oil, the highest result obtained being 17·2 lbs. Another test made by Oliver and Company gave the relative efficiency of coal and oil as 1 : 2.6. In a marine boiler fitted with the same apparatus, the engineer of Messrs. Wigham, Richardson, and Company is stated to have obtained an evaporation of 15·57 lbs. of water per lb. of oil. The liquid fuel which has been employed by Mr. Tarbutt in this country is the residual product known as "dead oil." In the use of the various steam-spraying apparatus it is necessary first to raise steam in the boiler by the use of some other fuel, or to employ an independent steam-generating appliance until the boiler has been sufficiently heated.

It is well known that Admiral Selwyn claims to have obtained in the use of liquid fuel far more satisfactory results than those which I have given. Liquid fuel occupies only slightly less space than coal, but its greater steam-generating power obviously enables a steamer to make a much longer voyage without taking in a further supply. Liquid fuel can also be placed on board far more quickly and with far less annoyance to passengers, advantages which will be appreciated by those who have made a long sea voyage in a steamship. Besides which, nearly the whole of the labour expended in trimming the coal and stoking is saved; and in the case of ships of war the smokeless character of the combustion is a feature of no small importance.

I have already referred to the use of the Nobel "trough burner" in metallurgical operations. With this apparatus I saw pure iron reduced to a liquid state, and if the air supplied were heated, a still higher temperature could be obtained. Liquid fuel is much used in Russian foundries, its purity giving it a considerable advantage over coal; and at the Norway Ironworks at Boston, Mass., it is preferred to gas or solid fuel. In some experiments, made in 1879 at the Brooklyn Navy Yard, with a mixture of petroleum and pitch blown into the furnace with superheated steam, iron was melted in 10 minutes, and glass in 2 hours, as compared with 2 hours and 16 hours respectively when coal was used.

I have also referred to the use of natural gas in the rolling mills at Pittsburg, as well as for heating the steam boilers used in drilling and pumping. In January, 1885, Mr. Andrew Carnegie stated that "already four distinct pipe-lines, two of them eight inches in diameter, convey the gas from this district [Murraysville, Westmoreland County],' to manufacturing establishments in Pittsburg, and a fifth line conveys it to our Bessemer steel mills, nine and ten miles distant. Another line of ten-inch pipe is being laid." Mr. Ashburner, writing at the end of last year, states that it is estimated that there are at present being supplied with natural gas in the city of Pittsburg alone, 1,500 dwellings, 66 glass factories, 34 rolling mills, and 45 other industrial establishments, and that about 10,000 tons of coal are thereby displaced daily. It is only within the past two or three years that natural gas has been largely used in industrial operations in the United States, but the gas has long been commonly employed as fuel in culinary operations and for warming dwellings throughout the oil districts of that country. The gas is consumed in Bunsen burners, and in one locality that I visited a charge is made for it at the rate of $4 per month per stove. Lampblack, of excellent quality, is made to a large extent in the United States by the imperfect combustion of natural gas.

Natural gas has been used from time immemorial in lime burning in the Caucasus, the gas being evolved from the ground in some localities in the neighbourhood of Baku in such quantity that the lime burner simply has to loosen the earth, apply a light, and build a mound of limestone over the flame thus produced.

Petroleum is used as a substitute for coal-gas in gas-engines. In some cases, as I have explained, "air-gas" is first made by saturating air with the more volatile products of the distillation of petroleum. In other cases, as in that of Spiel's petroleum motor, the liquid hydrocarbon, petroleum spirit, or benzoline, is injected into the cylinder.

In treating of the methods of testing mineral oils, I have referred to some of the characteristics of lubricating oils, and I mentioned the determination of viscosity as being a test on which I should have more to say later. I have recently, at a meeting of the Society of Chemical Industry, dealt somewhat fully with the relation of viscosity to lubricating power, and described various methods of measuring the viscosity of an oil. The machines of Ingram and Stapfer, Thurston, Woodbury, and others, are designed for the purpose of directly testing lubricating power, but since it is admittedly extremely difficult to ascertain the conditions of the practical use of a lubricant, and still more difficult to reproduce them with certainty upon a testing machine, the conclusion to which I have come in the course of some experience in such work is that viscosity is on the whole the best measure of the lubricating power of an oil, the relation between the two being in the case of various mineral oils undoubtedly very close, and the determination of viscosity being a tolerably exact operation and less liable than the testing of lubricating power with the machines mentioned to give misleading results.

Mineral lubricating oils possess the great advantage over fixed oils, and especially over seed oils, of being practically free from any tendency to oxidation; cotton waste saturated with such oils is therefore not liable to spontaneous ignition. The admixture of mineral oils with fixed oils has been shown by the experiments of Coleman and Galletly in this country, of Dollfus in Alsace, and subsequently of Ordway and Atkinson in the United States, to largely reduce or overcome the tendency of the latter to become oxidised. Professor Ordway and Mr. Atkinson experimented at temperatures up to 190° Fahr., or even higher in certain cases, and usually continued the heating of the oiled cotton waste for six hours. They found that oils, such as linseed or cotton seed, peculiarly prone to oxidation, were liable to take fire even when mixed with as much as 75 per cent. of petroleum oil, while in the case of lard oil an admixture of 33 per cent. of petroleum spindle oil prevented spontaneous combustion under the conditions of the test, though an admixture of 32 per cent. did not. The previous experiments made by Mr. Coleman and Mr. Galletly at lower temperatures indicated that an admixture of from 30 to 50 per cent. of a mineral oil prevented the ignition of the fixed oils commonly employed. Obviously, the protective action of the mineral oil varies with the temperature to which the oiled cotton waste is exposed, but it may be said that to the extent to which mineral oil is present the tendency of the fixed oil to become spontaneously ignited is diminished.

Suitable mineral oils undergo no change when used to lubricate the cylinders and valves of high pressure steam-engines, whereas fixed oils, when used under such circumstances, become decomposed, and injury to the metallic surfaces results. Nothing but a pure mineral oil should therefore be used for the purpose.

A mineral lubricating oil should be of a viscosity suited to the pressure, speed, and temperature of the journal; of a flashing point sufficiently high to render the production of inflammable vapour impossible, and of such "cold-test" that the lubricators and bearings are not liable to be clogged by the deposition of solid hydrocarbons. Some operators attach a good deal of importance to the determination of the loss by evaporation on exposure for a lengthened period to a temperature considerably above that of the atmosphere, the evaporation, even in the case of oils of high flashing point, sometimes being considerable. Professor Ordway is of opinion that a spindle oil should not lose more than 5 per cent. of its weight when a circular piece of filtering paper about two-thirds of the diameter of an ordinary watch glass is saturated with it, and exposed for twelve hours to a temperature of 140 F. The oil should also be free from acid or other impurity that may act injuriously upon the metallic surfaces.

The semi-solid mixture of petroleum hydrocarbons, termed, in the British Pharmacopæia, *Paraffinum Molle*, is now largely used by pharmacists as a basis of ointments and for other purposes. A process for the manufacture of this substance was, as I have stated in a previous lecture, patented by the Chesebrough Manufacturing Company several years ago, and the company claim, with justice I believe, to have first introduced the product which they term vaseline, into commerce. It is also contended by the company that their patented process of manufacture is the only one yet devised which is capable of yielding satisfactory results, and that the "imitations" of vaseline found on the market are not suitable for some, at any rate, of the uses to which vaseline is applied. It is stated to be important in the manufacture of the substance to carefully select the crude oil, to conduct the evaporation of the volatile hydrocarbons present in such a manner as to prevent "cracking," and to purify the residue simply by filtration through animal charcoal, and without the use of acid or other chemical. The vaseline thus produced, they say, is free from any irritating properties, whereas a mixture of hydrocarbons purified in the usual manner by chemical treatment is liable to act injuriously upon delicate skins. Moreover, it is contended that the soft paraffin made by fusing together crystallised paraffin and heavy mineral oil cannot be kept without some separation of the oil occurring, and is more affected than true vaseline is by changes of temperature. Although much of this remains to be experimentally demonstrated, it seems reasonable to suppose that just as the best burning oil is that which is the most homogenous, or is composed of the fewest hydrocarbons, so the best soft paraffin for pharmaceutical purposes is that which consists of the semi-solid comparatively uncrystalline hydrocarbons obtained in the manner specified in the Chesebrough patent. It may be that the use of highly crystalline paraffin for pharmaceutical purposes is, as some contend, unobjectionable, but no doubt a mixture of hard paraffin and oil would be more liable to separate, or to be affected by changes of temperature, than a mixture of hydrocarbons of the proper consistency, none of which differed very greatly in melting point, and none of which had a marked tendency to crystallise. Be this as it may, however, it appears unquestionable that the pharmaceutical use of hydrocarbons which have been purified by chemical treatment, and though subsequently deprived of free acid may contain, as mineral oil sometimes does, sulphur compounds, should be discouraged. In this connection it must be borne in mind that vaseline is not sufficiently hard for certain uses, and that it is sometimes necessary to mix with it hard paraffin; but this is not a valid argument for the employment of what may be termed an artificial vaseline in the sense already specified, either for use alone or for mixing with hydrocarbons of a higher melting point. There has already been a good deal published on the subject of soft paraffin by practical pharmacists and others, but in my opinion considerable benefit would result from the conduct of a comprehensive series of systematic comparative experiments under varied conditions, and extending over a considerable period. It might then be possible to frame more precise and satisfactory tests for *Paraffinum Molle* than those which are specified in the Pharmacopœia. As the Chesebrough patent will shortly expire, and as other manufacturers are already supplying apparently similar products under other names, the official recognition of the mixture of undistilled and comparatively amorphous hydrocarbons could not well be regarded as encouraging the use of a proprietary article. There has been an undoubted reaction in regard to the very favourable opinions that were at first entertained of vaseline as a substitute for animal fats. The result of experience appears to be that while vaseline, owing to its unalterable character, is decidedly preferable to an animal fat as a vehicle for the local application of remedial agents, yet in cases where the locality of action is not superficial, and absorption of the unguent is required, vaseline is less suitable. As illustrating the variety of pharmaceutical and other uses to which vaseline is applied, I may direct your attention to the representative series of specimens on the table, for which I am indebted to the Chesebrough Company.

The miscellaneous uses to which the products of petroleum are applied are somewhat numerous. The treatment of seeds with mineral oil, prior to sowing, has been advocated as preventing the attacks of vermin; and it has also been suggested that fruit trees should be dressed with the oil with the object of arresting the development of insect life. The latter application requires, however, to be made with some caution, as it has been found that at certain states of their spring growth some trees are liable to be killed by such treatment. Mineral oils have also, in common with other oils, been used with great success in preventing the breaking of waves and making the sea smoother.

Paraffin is largely used to impregnate wooden matches and make them more combustible, and I have seen it applied in a thin coating to the heads of matches to render them waterproof. Dr. Stenhouse patented the application of paraffin to woollen fabrics to increase their strength and make them waterproof. Paraffin is also used for glazing frescoes and paper; for saturating gypsum figures; and by the laundress, in starching linen, to give a gloss. It has also been used for lining beer barrels. As a preservative for stone and wood, paraffin also answers well, and it forms a good protective coating for the labels and stoppers of bottles containing corrosive fluids. Paraffin is used in preserving eggs, and has been recommended also as a preservative covering for meat, fruit, and flowers. It also forms a good electrical insulator. One of the most recent uses is that which has been suggested by Mr. Joly, of Dublin, who finds that a good photometer disc-substitute may be made by placing between two suitably-shaped blocks of paraffin a sheet of tin-foil.

We have now accompanied from its birth to its cremation the mighty stream of petroleum which is ever flowing from the earth to supply the daily increasing demand. We have traced the oil from the derrick to the lamp and candlestick, from the petroleum well and shale distillery to the furnace and the bearings of machinery. We have now reached our goal, at this the close of our last meeting. If I have not succeeded, in spite of my efforts, in placing before you the interesting subject of our programme in its most attractive form, I venture to hope that I have enabled you to carry away an intelligent conception of this great industry, the rapid growth of which is without parallel in the history of the world's commerce. The use of petroleum products for illuminating purposes has often been said to have exercised a civilising influence of an important character, and there are those who contend that the degree of mental culture of a nation may be measured by the quantity of mineral oil consumed. There is, at any rate, no doubt whatever that the use of so cheap an illuminating agent has materially lengthened the available time for work, as well as for elevating recreation and improvement of the mind. It may, therefore, fairly be said that the introduction of mineral oils has largely increased the sum of human happiness, and rendered the labour of mankind more productive.

Miscellaneous.

COLONIAL AND INDIAN EXHIBITION.

The number of visitors to the Exhibition for the week ending July 24th, was 166,791; making a total since the opening of 1,970,398.

COLONIAL FORESTRY.*

Referring to the inquiries of the Select Committee on Forestry, and to the scheme which had been submitted to it by the Secretary of the Surveyo s' Institution, respecting a National School of Forestry, Professor Fream proceeded to deal with the present condition of forestry in the larger colonies. In Canada there is need of conservation of existing forests, and of tree-planting over the vast prairie regions; several of the provincial governments have moved in the matter, and everything now seems ripe for the establishment of a department of forest conservancy under the Dominion Government. In New South Wales, the Forest Conservancy Branch is under the Minister of Mines, and was established in 1877. There are 5,390,513 acres of land set apart as timber reserves, equivalent to 2·7 per cent. of the area of the colony. The salaries and expenses of the officers of the conservancy amount to nearly £10,000 per annum. The total expenditure from 1877 to 1884 was £75,923; the revenue, £85,992. Nurseries are being established for the propagation of the most suitable trees, indigenous and foreign. In Victoria, 952,367 acres of State forests, and 285,334 acres of timber reserves are, in conformity with the State Forests Conservancy Act, placed under the Department of Agriculture, but even this area is not commensurate with the demand for timber for industrial purposes. In 1883, the revenue from woods and forests was £8,580, and expenditure, £2,538. In South Australia, the Forest Conservancy is under the Commissioner of Crown Lands, and was established in 1876, since when the revenue has practically balanced the expenditure, and upwards of one and a half million trees have been added to the property of the colony at an actual cash disbursement of only about £2,000. The approximate value of permanent improvements is £115,000. The area devoted to forest purposes is 150,000 acres. In 1884, the Conservancy distributed gratis more than 200,000 young trees, at least, half of which survived transplantation, and cost the colony less than ½d. each. In Queensland there are twenty forest rangers under the Department of Public Lands, with 1,572,752 acres of proclaimed timber reserves, and 202,575 acres of reserves for State forests. One reserve is used as a plantation for growing seedlings for distribution. In New Zealand, out of a total area of 66,394,400 acres, 34,000,000 acres of Crown lands still remain, of which 10,000,000 acres are forest. Under the New Zealand State Forests Act, 1885, a Forestry Department has just been started, and is placed under a responsible Minister of the Crown, who acts as Commissioner of State Forests. The Government assists planting on the part of landowners, by subsidy or otherwise. In Cape Colony, by an Act passed in 1876, public bodies are allowed half their expenses in tree cultivation. There is a Superintendent of Woods and Forests, and conservancies have been established at Knysna, King William's Town, and in the Western Division. To encourage planting, over one million trees are raised annually in nurseries, and distributed gratis or at rates. It is believed that the Crown Forests would, if regularly and carefully worked, produce a revenue of at least £235,000—the sum which leaves the colony every year to pay for imported wood—for imported railway sleepers alone, £83,000 was expended in 1883, and £44,000 in 1884, on American and Swedish timber. In Australia and Cape Colony, English forest trees are being successfully cultivated. In all the colonies the reckless waste and wanton destruction of former days have given place to wise systems of conservancy, such as are worthy of a tree-loving people.

MARINE WOOL.

The manufacture of articles from marine wool, or *bisso*, is an industry carried on, only on a limited scale, on the coast of Sardinia, and more particularly at the island of the Madalena; if the product was better known, it might become an important branch of trade, insomuch as, from the softness of the texture of this substance, its natural colour and durability, *bisso*, instead of being, as it is now, a simple object of curiosity, merits a place in everyday use.

The *bisso*, or golden wool, is obtained from the *Pinna nobilis*, a mollusca belonging to a genus of shell fish which attaches itself to rocks and stones at the bottom of the sea by means of a tuft of a fibrous hair-like substance. This tuft is usually of a yellowish-brown colour, of a silk-like texture, with a brilliant metallic lustre, and is found in great quantities in the numerous little bays and creeks on the coast of Sardinia, and more especially on the shores of the islands of Caprera and La Madalena. The *pinna* is one of the largest bivalves found in the Mediterranean, and the great *pinna* is known at Madalena by the name of *gnacchera*, or *nacchera*; in the Venetian dialect as *gnaccara*, which name is probably derived from the Spanish *nacara*, signifying a sea shell; whilst the same word in that language, *nacre*, in French signifies mother-of-pearl. *Bisso* appears to have been known to the ancients, as Pliny, in his "Natural History," makes mention of its being found at Taranto, but as being little used.

The implements used for collecting this shell fish is simply an oval-shaped ring of strong iron wire, called locally *ferro di nacchera*, which is fixed at the end of a rod from 15 to 20 feet in length, and the *pinna* is disengaged from the rocks and brought up to the surface by this instrument. The fish, which is somewhat indigestible, is used as an article of food by the fishermen, the edible part being well washed and rubbed on a rough surface in order to free it from a bitter tasting substance of a reddish-brown colour which it contains, and called locally *pepe* (pepper).

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* Abstract of a paper read by Professor W. Fream, at the Colonial and Indian Exhibition, on Wednesday, 30th June.

The tuft of wool is then washed first in salt water, in order to free it from the sand, fragments of shells, and other substances that may be entangled in its fibres, and after a second washing in cold water it is dried in the sun. When dry it is combed and the tuft remaining is cut from the root by which it is attached to the shell, and it is next spun like cotton, wool, or other textile substances. The combings also can be spun, but yield an inferior quality of yarn. The *bisso* is of two colours, or rather two shades of the same line particular to it, either dark or light, the latter being the most prized on account of the rich dark gold lustre (*Vielle or*), from which its name "golden wool" is derived. On account of the small quantity in which it is collected, the little care taken in sorting, the stuffs made from this wool are often striped with dark and light shades. Oysters of excellent quality often attach themselves to the shells of the *nacchera*. These shells might be used as an inferior quality of mother-of-pearl. The pearls that are occasionally found in these shells are usually of a light brown or copper colour, sometimes of a reddish tint, and more rarely of a white or rather a dirty white. The price of *bisso* is as follows:—When simply washed and dried, 7 lire per kilog. (2s. 6d. per lb.); combed, 15 lire per kilog. (5s. 7½d. lb.); and when carded and spun, at 30 lire per kilog. (11s. 3d. per lb.) The cost of spinning is 7·50 lire per kilog. (2s. 7¾d.) The fibre loses about 25 per cent. of its weight by combing and spinning.

The price of articles manufactured from this wool are cravats 5 lire each (4s.), small shawls from 25 lire to 30 lire (£1 to £1 4s.); they are extremely durable, and a shawl costing originally 60 lire (£2 8s.), which has been in constant wear in all kinds of weather for upwards of twelve years, was lately seen by the writer.

Correspondence.

ACTION OF LIGHT ON WATER COLOURS.

I have the honour to request that you will be so good as to allow me to state in the *Journal of the Society of Arts* that the Lords of the Committee of Council on Education have appointed a committee, consisting of Sir F. Leighton (chairman), Mr. Poynter, Mr. Alma Tadema; Mr. Carl Haag and Mr. Henry Wallis, named by the Royal Society of Water Colours; Sir J. D. Linton and Mr. F. Dillon by the Royal Institute of Painters in Water Colours; together with Mr. Sidney Colvin, of the British Museum, and Mr. Armstrong of this Department, to consider the question of the action of light on paintings in water colours. Captain Abney and Dr. Russell, who have for some time past been making a scientific investigation of the action of light on the various pigments used in painting, will inform the committee of artists of the method and nature of the inquiry. With this information before them, the committee will be in a position to judge whether there are any further points which they would desire to suggest to Capt. Abney and Dr. Russell for investigation, or whether there is any inquiry they would themselves wish to carry on.

J. F. D. DONNELLY.

Science and Art Department,
23rd July, 1886.

Obituary.

SIR JOHN ANDERSON, LL.D.—Sir John Anderson, who had been a member of the Society of Arts for thirty-one years, died at St. Leonards-on-Sea, on Wednesday, 28th inst., in his seventy-second year. Sir John was for many years Superintendent of Machinery in the Royal Gun Factory at Woolwich Arsenal, and he received a knighthood after his return from the Paris Exhibition of 1878, where he acted as a juror. He read a paper before the Society of Arts in January, 1857, on the "Application of Machinery in the War Department;" and in 1869 delivered a course of Cantor Lectures on "Applied Mechanics." When the Technological Examinations were started by the Society he was appointed examiner in the subject of "Steel." Sir John Anderson presented a free library to his native village of Woodside, near Aberdeen, a few years ago.

DAVID STEVENSON, F.R.S.E.—Mr. D. Stevenson, one of the engineers to the Board of Northern Lighthouses and the Fishery Board of Scotland for Harbours, died at North Berwick on Saturday, 17th inst. Mr. Stevenson was the third son of Robert Stevenson, the engineer of the Bell Rock Lighthouse. He was born at Edinburgh, in January, 1815, and his first professional engagement after completing his apprenticeship was on the Liverpool and Manchester Railway, under Mr. Mackenzie, the contractor. He read a paper on this scheme before the Royal Scottish Society of Arts, and received one of that Society's medals. In 1837, he made a professional tour in Canada and in the United States, the results of which he published in a work issued in Weale's series, under the title of "Sketch of Civil Engineering in North America." He was elected a member of the Institution of Civil Engineers in 1844. He was the author of articles in the *Encyclopædia Britannica*, and of several distinct works, one of these being the life of his father, published in 1878. Mr. Stevenson was elected a member of the Society of Arts in 1873.

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FRIDAY, AUGUST 6, 1886.

PRINCE OF WALES'S TESTIMONIAL FUND.

Members of the Society desiring to take part in the subscription to the above fund can obtain collection forms from the Secretary, who will also be happy to receive, for transmission to the Hon. Secretaries of the Fund, any subscriptions from members or their friends. No subscription is to exceed two guineas. Contributions may also be sent direct to the Hon. Secretaries to the "Prince of Wales's Testimonial Fund," Bank of England, Burlington-gardens, London, W.

It is the desire of the Testimonial Committee to preserve the names of all subscribers. Names and addresses should, therefore, be carefully given.

H. TRUEMAN WOOD, *Secretary.*

Proceedings of the Society.

CANTOR LECTURES.

THE ARTS OF TAPESTRY-MAKING AND EMBROIDERY.

BY ALAN S. COLE.

Lecture I.—Delivered April 5th, 1886.

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The subjects of the Cantor lectures which the Society of Arts have kindly invited me to deliver are Tapestry-making and Embroidery. These are two branches of the comprehensive group of textile manufactures and ornamentation; and although we may perceive some resemblances in methods of execution between the weaving of textiles, the making of tapestries, and certain forms of embroidery, there are sufficiently marked differences to entitle each branch to be separately discussed.

The patterns and ornament of textiles also form a distinct topic, affecting both tapestry-making and embroidery. But in a necessarily limited and preliminary lecture I do not think that one could very usefully try to indicate the classes or groups of ornament peculiar to each process. The closer one looks into the ornamental character of things, the more the conclusion seems to present itself that all ornamentation, in whatever material it may be expressed, is to be viewed as a long chain of many links. The chief part of my lecture this evening will, therefore, relate to a development of pattern.

Certain processes of manufacture have undoubtedly affected the expression of ornamental effects; and, *vice versâ*, the attempt to produce certain ornamental shapes and effects by methods which have not readily lent themselves to the attempt has sometimes brought about modifications of methods.

Sewing, as used for uniting furs and skins together, may, in some cases, precede weaving in a procession of human crafts; but weaving in a loom with a shuttle appears to be the senior of processes pertaining to textile manufactures. Embroidery, which is a development of sewing, comes as a handmaid to weaving. In fact, embroidery postulates weaving, as a rule, since it requires a woven foundation to start from, although the embroidery with horse-hair and beads upon leather, such as the wampam of American Indians, and other tribes in our own hemisphere, is an exception. That, however, does not diminish the significance of the fact that embroidery has been done upon a woven foundation from the earliest known times.

Tapestry-making, as applied to the production of large pieces, is, perhaps, a later process than weaving and embroidery. The apparatus for making tapestry is more involved than that for simple weaving and embroidery. In a genealogy of processes, it would be hardly correct to assign to tapestry-making a position as the offspring of the far older process of carpet-making, which, however, it closely resembles. So far as one can trace it from actual results of the process, tapestry-making in respect of large hangings for use in tents, or buildings, may, perhaps, be considered to be European, and dating from about the 12th century. Before this time, hangings, but probably of light texture, had been put to uses like those to which tapestry came to be devoted. A process analogous to if not identical with that which we shall next Monday see is peculiar to tapestry, had existed for centuries, and had been employed by Oriental people like the Egyptians, Syrians, Tartar, and Tibetan tribes, and possibly Arabs. But distinct evidence that such a process is one of the earliest known to textile makers is not forthcoming in the same way as the indications that simple weaving was one of the necessary and primary human arts or processes amongst people in all parts of the world. As time went on, and goes on, modifications were, and are still, made in the weaving apparatus, the frame, the cylinders, the working of the warp, the number of the shuttles, and so forth; but the main principle of the process has remained the same from all time; and the primitive methods prevail amongst primitive people, as may be gathered from illustrations of weaving which are supplied to us from people such as the natives of Ishogo, a place in that district of West Africa, between the Congo and Gaboon Rivers.

And now turning to the principal subject of my first lecture, I would say that, whilst the ornaments or patterns which have been expressed are very varied, reflecting phases of ingenuous and conventional fancy and rendering for thousands of years, the use of primitive and simple forms of ornament also survives. Not only are there these survivals, but there are recurrent appearances of more elaborate ornament, the elementary components of which are apparently to be traced to simple and primitive forms. It would be misleading were I to exemplify these ornaments merely in respect of tapestries and embroideries. I have, therefore, collected together a few diagrams from various sources, and with these I venture to very slightly suggest a development of patterns.

It is usual to display the history of art and its development by taking records of the earliest historic periods, and attributing to each of the famous nationalities of the world a credit for having produced some distinctive style. Under this method of treatment, we may first discuss the Egyptians, then the Assyrians, then the Greeks, whose rapid attainment to artistic supremacy seems to isolate them from the Egyptians and Assyrians. The Romans follow the Greeks, and a decline in quality ensues. A somewhat vague Romanesque and Byzantine nationality—though it might more properly be termed "period"—of art is then traced; after which the germs and their blossom of the Renaissance and Gothic styles in Italy, Germany, Flanders, France, England, and Spain are discovered, to be succeeded by developments of antecedent styles, as displayed in certain classes, under titles belonging to royal families and sovereigns, such as Tudor, Elizabethan, Jacobean, Louis XIV., XV., and XVI., Georgian and Empire. To this general scheme, types of Celtic and Scandinavian art, Moorish, Arabic, Syrian, Persian, Indian, Chinese, and Japanese art either form a sort of supplement, or are occasionally alluded to as circumstances may seem to invite; whilst art, as expressed by people like the natives of the Congo, the New Zealander, and the Toltec or the Aztec of Central America, is dealt with as though it were outside the pale, and possessed a peculiar interest of its own, having virtually nothing in common with the previously named styles.

The term art or skill can be applied to all branches of human work. And in its relation to expressions of form and colour, and to processes or handicrafts, rather than to countries or periods, I propose to consider it in the course of my lectures. For after all what is nationality in art? Is it possible to take any phase of art and maintain that its creation, as distinct from those features which one groups as pertaining to individuality of treatment, is peculiar and due to a single man, and its rearing to a single nation? The greatest geniuses could not have done what they did without work, and the influence of such work, having preceded them. Commerce, in a broad sense between peoples, has from undateable periods distributed the works of human labour and ingenuity, sometimes where wit was keen to act under their influence, sometimes where wit was slow. The rare individual genius carries the art, whatever it may be, a stage further than has previously been reached; whilst others of less ability emulate some chosen example, and in so doing either maintain or obscure the influence of traditions. So far, then, as history of art may be written, and especially perhaps of art in Europe, this practical handing on and modifying of its traditions through retrogressive as well as progressive stages of emulation involves a cosmopolitan survey. Circumstances of isolation, stagnation in custom, and interruption of social arrangements and habits, have been contributory causes to the stereotyping of certain level standards of performance in productions which, through likeness one to another, are subsequently regarded as components of a national style, such for instance as the Assyrian, Egyptian, and Romanesque styles. But national style of art in this sense might be held to be demonstrated by cognate works showing more often a comparative absence than predominance of complete ability. Consequently, to detach and consider by itself some one or other national series of emulative works, impairs the view of development of art for its own sake.

Carlyle writes that the first spiritual want of man is decoration, a statement involving a cosmopolitan aspect of man, and implying a common want and a common response, throughout the period that man has been in the world. Similar conditions of life, according to authorities upon climate, geology, and biology, repeat themselves during the course of hundreds of thousands of years. The climate, for instance, of the lower miocene stage prevailed in Europe long before signs of man can be traced; and yet a similar climate now prevails at Louisiana, North Africa, and South China, where man exists. The antiquity of geological records, from which such facts I believe are deduced, is overwhelming in contemplation, as compared with that of the records of human art. Still, if one could adopt a similar view as to the recurrence or succession of marked phases of artistic decorative and ornamental work, the demonstration of an evolution of such work would be possible, although it would, I expect, be a matter of nice discernment to select normal types to fully illustrate it.

Now, decoration as the response to "the first spiritual want of man," may for our present purposes be divided into two broad divisions, the one in which the representation of actual things occurs, the other in which abstract forms are displayed. A line and a dot I may suggest as simple abstract forms, elements that we might expect to find in the first works of decoration. Nevertheless, it is, I think, a striking fact that, chronologically taken, the first specimens of graphic art at present known to us gives us not only representations of animals but also of human habits, like hunting.

These were scratched on bones of animals by cavemen many thousands of years before the Egyptians, of whose skill in representing actual things and abstract forms we have records going back to more than 5,000 years ago.

The art or skill in the drawing, as we see by these diagrams thrown on the screen, indicates a facility and fidelity of representation which belong, according to our notions, more to a trained draughtsman than to so presumably barbaric a creature as a caveman. As Mr. Boyd Dawkins points out, a somewhat similar graphic skill displays itself in engravings on bone by the Eskimos of the present time, and it would seem that the conditions of their life are not far removed in likeness from those of the cavemen. But I think it will be allowed that the graphic skill of the cavemen should take a higher position in an evolution of skill than that of the modern Eskimos. From the evidences furnished by the cavemen, we are not, I think, forced to conclude that pattern making with abstract forms did not co-exist with the power of sketching animals.

And here I would show you a series of simple abstract forms taken from various sources, from the combination of which patterns have arisen.

First we have repeated lines (Fig. 1, A) graven on pre-historic pottery; then zig-zag (B, C, D.) The square (E), the square within a square (F), and what is commonly known as key pattern (G, H), (Fig. 2, I, J, K, L), are used as simple abstract forms by people of primitive and advanced culture. Certain elaborations of patterns with straight lines are seen as admirably carried out in the fine plaitings and well-ordered carvings of savages as they are in the geometric patterns of the Chinese, Japanese, and those people grouped as Saracenic. Ornament based on circular and curved lines

Fig. 1.

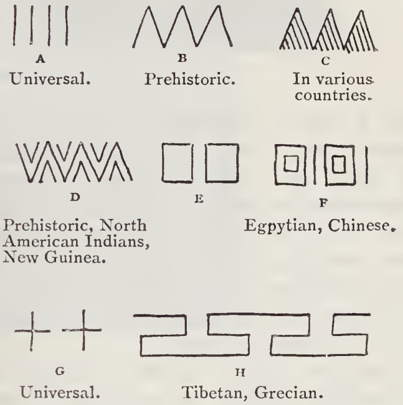
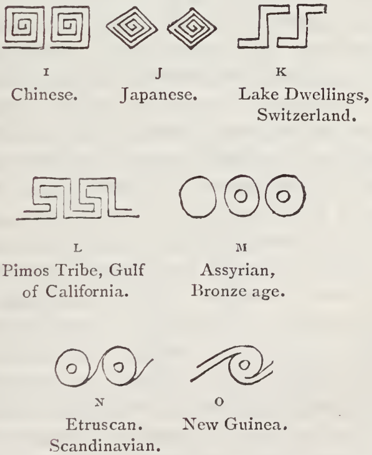
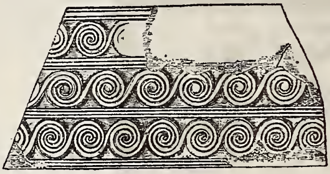

A
Universal.
B
Prehistoric.
C
In various countries.
D
Prehistoric, North American Indians, New Guinea.
E
F
Egpytian, Chinese.
G
Universal.
H
Tibetan, Grecian.

Fig. 2.


I
Chinese.
J
Japanese.
K
Lake Dwellings, Switzerland.
L
Pimos Tribe, Gulf of California.
M
Assyrian, Bronze age.
N
Etruscan. Scandinavian.
O
New Guinea.

seems to be as early in its appearance as that made with straight lines. The circle and concentric circles are elements in primitive ornaments (M). By the introduction of a curved line between a pair of double concentric circle forms (N) we have the suggestion of a spiral, and this suggestion is carried a stage further by so primitive a being as a native of New Guinea (O). The origin of the spiral (Fig. 3) has, I believe, been a subject of profound discussion, and it seems to be a form not so purely abstract as those we have previously looked at. Some spirals resemble those in shells or the fronds of ferns, others again may have arisen from coils of string or wire, and others from the convolutions on the flesh of fingers. This latter class of spiral is used by New Zealanders for their tattoo ornaments.

FIG. 3.



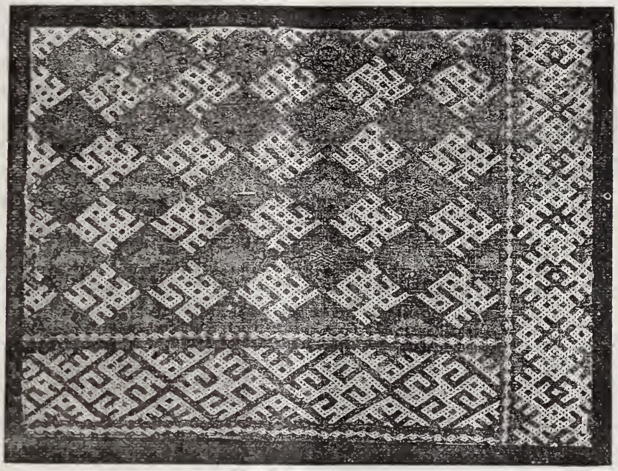
Thus the variety of actual things, from representing which an ornament like the spiral may arise, is sufficient probably to account, if need be, for a number of independent appearances of apparently the same ornament. The same sort of remark applies to many other ornamental forms. As the study of ornament proceeds, forms having an apparent likeness to one another can be grouped together as generic types in one large family; and the influence of dimensions of space—length and breadth—is seen to have effected the use of such types in the making of patterns. A sense of length has operated in producing horizontal patterns, whilst breadth or height has assisted in producing perpendicular ornament. A sense of surface, limited by length and breadth, has helped to generate the scattering of forms in horizontal and perpendicular series, an arrangement very noticeable in diapers, such, for instance, as we observe in this Assyrian King's costume. The diagram shown on the screen is taken from a drawing of a sculpture done about 800 years B.C. Another example of the use of ornamental diapering is to be seen in a sculpture from the Usumacinta River, in Central America, possibly carved by an Aztec artist of the 13th or 14th century.

I hope that these suggestions may have been sufficient to establish the fact that schemes of arrangement are to be deduced from the simplest of patterns, and that although these schemes have a relationship one to another, they may possibly and probably, like the representation of forms, have grown into usage quite independently of any such factor as inter-imitation.

But a vast quantity of patterns has been made which have been imitated and adapted from one to another. The opportunities of imitation, such as those furnished by intercourse, whether arising from peaceful or warlike conditions, have recurred from the earliest of times. It is, therefore, an almost hopeless task to discover absolute originality in any production. Theorising upon the development of pattern, one seems to see that monotony of symmetry, for instance, educes a desire for contrast of some sort. Both symmetry and its contrast are conspicuous in elaborated details and masses of ornament compounded of abstract forms and quasi-representation of actual things. When certain ornamental effects are attempted, the unconstrained representation of the actual appearance of things is affected by conditions such as those which arise from the nature of the material in which these effects are to be rendered, the use of the object, and the shape of the whole or that part of it which it is intended to decorate. For instance, from the method of cross stitch embroidery, which is usually regulated by the rectangular lines of the woven material upon which the embroidery is done, rectangular rendering of things ensues, as in this specimen (Fig. 4, p. 935) (made perhaps in Germany during the 16th or 17th centuries), where it was suggested that some Persian characters were depicted. The suggestion, however, does not bear the test of close scrutiny, since we trace bird forms in the device, which is repeated and scattered in a diapering pattern over the main portion of the specimen. We see that the device itself is made up of an oblong body resting on two feet; a neck with square head and straight beak, is bent backwards over the body—as in the gait of a waddling duck—whilst from the extremity of the back rises a device suggestive of an upturned tail. This, then, whatever may be its origin, is no mere arrangement of lines to produce an abstract form; it possesses a distinct meaning, notwithstanding that its value in representing a bird is somewhat obscured. Similar rectangular renderings of animals is furnished by tent stitch embroidery from

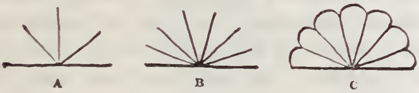
Anatolia. Many shapes in woven textiles and carpets from Tartar tribes have become so contorted by the special process in which they have been rendered, that one loses trace of their having started originally from abstract forms or from the representation of actual things. The same characteristic is observable in certain classes of ornament made by strict Mohammedans, whose reverence for religious doctrines prevents them from actually depicting living objects. The orderly arrangement of the odd-shaped details, however, predominates, and gives them value as patterns.

Fig. 4.



North German Embroidery, ? 16th Century.

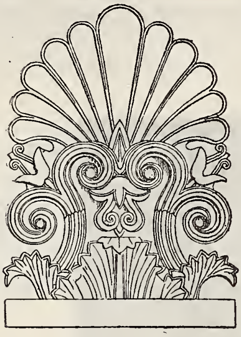
Fig. 5.



But reverting to the monotony which makes one wish for change, and applying this feeling in respect of a primitive ornamentist who had got as far as making a pattern like A of Fig. 5, we might fairly, I think, suppose that he would seek to make some change by introducing some additional lines. In such a pattern, then, as B, his pleasure in radiation of lines evidently rules him. But the slight alteration he had thus made might not satisfy him; and as his power of drawing might not be limited to straight lines only, he might use curved lines; and by adding curved lines to the ends of his radiating lines, he might make a more complete looking figure, such as C. Palm trees spread their leaves out in a radiating manner; so that a pattern maker, dominated by the pleasure of seeing radiations, might, in his ambition to make forms, be influenced by the appearance of the palm. From very early times the palm has been venerated in the East as a holy tree. An early Assyrian symbolical ornament, simple or primitive in construction, was produced by a pattern maker who may or may not have been able to analyse his sense of radiating shapes. The likeness between the radiating motives in this symbolical ornament and the pictorial representation of palms may be seen if we refer to an Assyrian bas-relief from Nineveh, in which a row of palm trees appears at the back of a procession of water-carriers. Some centuries earlier Solomon uses the palm as an ornamental detail for adorning the Temple (see 1 Kings, vi. 29).

The veneration of symbols such as the palm ornament with its radiating lines, helped to fix the use of such symbols for many centuries (quite apart from sense of their æsthetic fitness). The same condition occurred in Egypt, in regard to the lotus plant and flower, of which ornamental renderings became fixed by religious discipline. Thus types of ornament pervaded such countries; and it was not until desire for variety went beyond a conservative power of religious doctrine, as for instance in the Greeks, that new shapes, apparently based upon a perception of those previously used, arose, and the "anthemion," or honeysuckle, as it is termed, was designed (Fig. 6). In this the essential feature of radiating lines is prominent, no matter whether the forms are like details in the honeysuckle blossom or not.

Fig. 6.



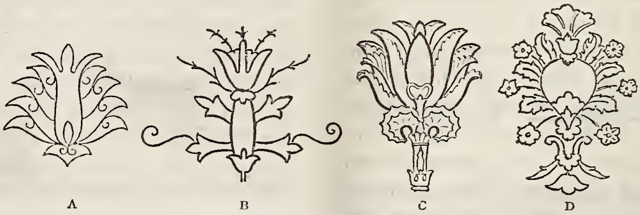
Another example of motive and arrangement of motive in design, which was adhered to a good deal in consequence of an associated religious value, has been discussed by Sir George Birdwood. This motive consists of a bud and blossom in repeated alternations, and is known as the knop and flower ornament. A sense of alternation, as an effective and simple means of contrast, seems to be universal amongst ornamentists, so that such a motive as this blossom and bud arrangement may spring into existence and be adopted, apart from the influence of sectarian doctrines.

The pine cone, the Jerusalem artichoke, the pineapple, and such like, have a common resemblance to one another, in appearance of successive diamond shapes, presented by the overlapping of their leaves or scales within a tapering oval shape. And this device, which relies for its effect upon a sort of radiation, has educed inventiveness in pattern makers. The vogue which this cone or pine motive with radiating cross lines has had in a long series of variations, may no doubt have been influenced by the religious significance with which it was invested thousands of years ago in the East. But I venture to think that the attractiveness of radiating lines has had as much to say to its later adoption as its symbolism had to its earlier wide-spread use.

Such motives are well known in patterns for surfaces, for European costumes and hangings of the 15th and 16th century, as well as for woven fabrics, some of which, nominally made at Venice, are evidently very close reproductions of similar stuffs, if not the originals, made in the East. Here, again, are a few diagrams of ornaments in which the radiation of lines upon the plan of the Greek anthemion is an essential feature common to them all.

The ornament from Ispahan (C of Fig. 7) of the 5th century, with a central fruit form, may in some distant way be related to D, the Italian ornament of the 16th century in which the fruit form is more pronounced, whilst B, the so-called English ornament of the 14th century, seems also to be connected in likeness with them and with A, the Chinese specimen as well.

Fig. 7.



Coincidences like these are interesting. We find counterparts of them in other results of human labour and thought, such as literature, or the art of writing and telling about things as distinguished from the art of depicting them; and a small book, entitled "Customs and Myth," written by Mr. Andrew Lang, abounds with them. Mythology and history have had a considerable effect upon producers of works of art. Scarcely a Greek sculpture exists that is not discovered to illustrate some event or personage of mythology and history. Here, for instance, we have a photograph of the group of Jove's eagle carrying off a youth—Ganymede—to serve as cup-bearer to the gods. It is considered to be the work of Leochares, the famous Greek sculptor, about 350 years B.C.

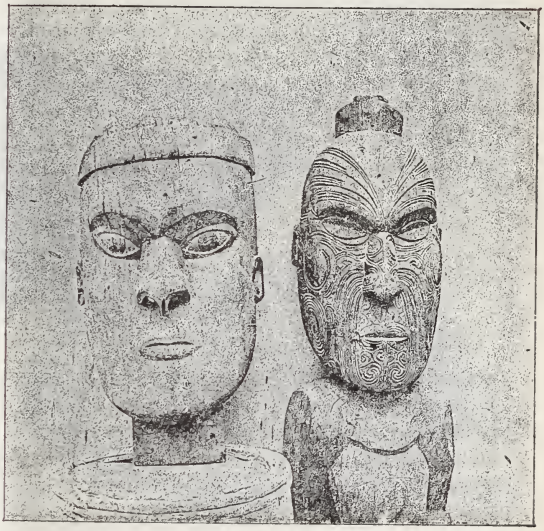
Here is evidently another version of the same sort of story. This, as we see, is part of the decoration of a golden jug or vase, which, with other treasures, was discovered in 1799 in Hungary, in a district associated with the warlike tribe of Gepidæ, which settled on the banks of the Danube. But whether this vase was the work of an artificer working under the influence of Perso-Roman or Sassanian ideas, of Scythic or of Græco-Asiatic thought, it has not yet been decided by the learned in these matters. Still, there is a justifiable feeling that this jug was made about the third or fourth centuries A.D., though somewhat similar style and design appear in European works of later centuries.

Now, on another vase of the same time we find a somewhat similar group of a human being in the clutches of an eagle; but the human being, upon inspection, is a woman, so that this second incident depicted clearly does not relate to Ganymede.

From this specimen I pass to a photograph of a sculpture lately discovered with many others at Sanghao, in a north-western district of India. I have taken this from one of a series of interesting monographs beautifully illustrated, published, under the supervision of my brother, Major Cole, R.E., by the Government of India. According to archæologists, the event here shown belongs not to Greek mythology but to that of Buddhism. The woman is said to be the mother of Buddha Sakya Muni, who was carried up to the Trayastrinsha heavens, to be there regenerated after her death. This sculpture may perhaps be regarded as the work of a carver about on a par, in quality of design and workmanship, with the producer of the Scythic or Græco-Asiatic vase. Both workers are removed from each other by great lapses of time. The carver of the Buddistic episode presumably worked about the beginning of the Christian era, and, as I have said, in a north-western corner of India, at Sanghao. This place is some three or four hundred miles from the ancient Sogdiana, where Alexander the Great 300 B.C. settled for a few months, during his expedition into Bactria. Architectural remains and pieces of sculpture have been found in north-western districts of India, and are often spoken of as Græco-Bactrian, and Græco-Buddhist. As evidences in expounding a development of art, the Græco-Asiatic and Græco-Buddhist figures might fairly be classed together as illustrative of a phase of attainment much in the same way as we classed the simple ornamental arrangements we looked at during the earlier portion of the lecture. Both indicate a lower level in performance than that of Leochares' work, and might be regarded either as deteriorations from that level or as aspirations to attain to it.

Deterioration from or aspiration to something better, are extremely interesting qualities to detect in a development of art, and in this connection I propose to refer to samples of the artistic expressions of the New Zealander; not, however, that I can in any way suggest the stage of development to or from which this type of ornament may be ascending or descending. Broadly speaking, two foremost motives in ornament from New Zealand are the human figure and spirals. But the New Zealanders, like many other people whose condition of life and habits is different from our own, make realistic imitations of things as well as ornamental devices with abstract forms. The quality of their realistic works is shown in carved heads like these (Fig. 8) which have, I believe, the prime purpose of displaying portraits, the one of a man not tattooed, the other of one tattooed.

Fig. 8.



We may look at a piece of ornamented pierced work in which spirals are alternated with human figures, and therein detect how the New Zealander's appreciation of contrast and of balancing forms affects his patterns. And now we pass to a canoe prow (Fig. 9, p. 938).* The main lines of the prow are emphasised, and separate the various portions which are ornamented. Two spirals corresponding with one another are so arranged as to give another proof of the New Zealander's sense of balance of form. Between them are other shapes, also arranged in an orderly manner, and again expressing his sense of balance of form. Below is a narrow space filled in with curves producing contrast with the rigid boundary lines of the space itself. It is evident, I think, from the way in which the curvings and other forms are grouped into this space of irregular shape, that the limits of space have affected the arrangement of the details in such a way that the meaning of them is well nigh lost. This squeezing in of details to fill a given space is a practice often demonstrated in other varieties of ornament. Beginning with this lower right hand corner of the prow, we may distinguish a grotesque human figure. Its head is set nearly at right angles to its body. Its eyes gleam from beneath two angular brows—the forehead is low—the nose small. A large broad lipped oval forms the mouth, into which is thrust three figures which do duty for the whole hand. Then comes the arm of this hand, starting abruptly from a plum-shaped body. Across the body we see three fingers like those in the mouth, and the arm belonging to them is set a-kimbo, the two legs are straddled outwards. This odd rendering of the human figure constantly recurs in New Zealand ornament. The pattern on its surface perhaps represents tatoo marks. Beyond the human figure are horn-shaped and twisting details, also covered with tatoo marks. Upon some of them we see the three fingers. Now, if we look at the device set between the two spirals in the upper part of the canoe head, the three finger device, thrust into an open oval and a pair of eyes will be found; thus indicating—obscurely perhaps—that the motive of this open pattern is the human head. In a second similar New Zealand prow we find the human figure in the lower space more grotesque through distortion than in the corresponding space of the first prow we looked at, and this distortion in the second prow arises no doubt from the artist of this piece being less skilful than the artist of the first. Nevertheless, in this second piece we recognise the same general characteristics which, as it were, give a style to this method of using and depicting forms. It is likely that both were wrought during the present century, though I am not aware of any circumstances why they might not have been produced in previous centuries. It is allowable, I think, to conceive that, in the course of years, as other New Zealanders imitate with variations what has gone before, at the same time developing their compliance with rules as to balance of forms in arrangement, contrast, and so forth, a perfectly different style of ornament may arise in which there will be little, if any, trace of the distorted human figure.

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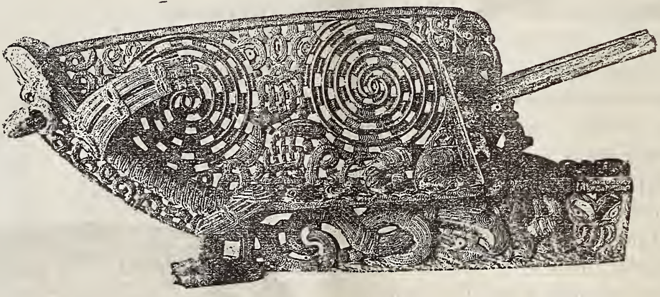
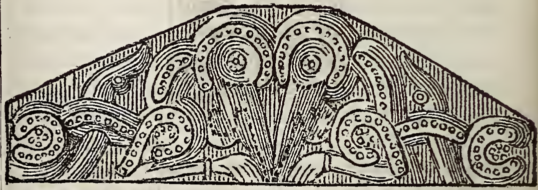
* This specimen belongs to H.R.H. the Duke of Edinburgh, who kindly allowed it to be photographed.

Fig. 9.



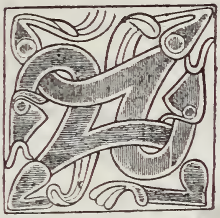
Now distortion in representing figures and their arrangement may be observed in other phases of ornament with which New Zealanders have apparently no connection, and by way of illustration we may refer to one or two examples of Scandinavian design emanating from the earlier iron age, which for convenience one may roughly date between the 4th and 11th centuries of the Christian era. Here is a specimen of ornament (Fig. 10) from Scandinavia, the grotesqueness of which is not very remote

Fig. 10.



from that of the New Zealander's. The subject here is animal form, two figures with goggle eyes, pointed snout, and almost human paws, are figured opposite to one another. The tail of each curls up towards the back of the head. The shape of the space into which these details have been grouped has affected their general arrangement. The idea of animals placed *vis-a-vis* is very ancient in its connection with pattern, and long before this grotesque rendering (Fig. 10, p. 938) of that idea was made, other more perfect renderings had been produced. It may not, therefore, surprise you to hear that Dr. Hans Hildebrand, Royal Antiquary of Sweden, considers this pattern to represent two lions *couchants*. Lions *couchants* and *vis-a-vis* often appear in Roman ornament, as well, indeed, as in many other types of ornament, and this motive has been adopted by Teutonic tribes, who have remodelled it according to the exigencies of their taste, or as far as their limited skill permitted them.

Fig. 11.



A further transformation of the lion motive, gives us the so-called lion shapes intersecting one another, and, as it were, squeezed up to fit a square space (Fig. 11). The corrupted representation of the animals has become still more unlike the Roman rendering—the forms are no longer *vis-a vis* to one another, but are interlaced. A likeness in details between this and the first of the Scandinavian renderings is, however, noticeable. Symmetrical distribution and balance of forms grow in emphasis, as the likeness to animal forms—always obscure—declines (Fig. 12). Other and later specimens show further developments of the two lion subjects. The increased elaboration in interlacing the forms marks a still further developed skill on the part of the designers in symmetrically arranging forms in a given space (Fig. 13).

Fig. 12.

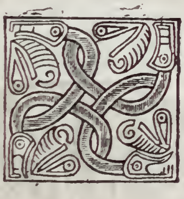
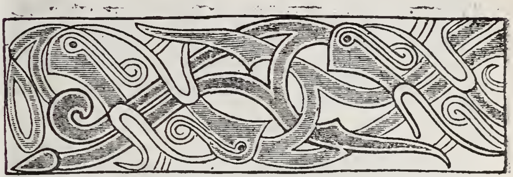
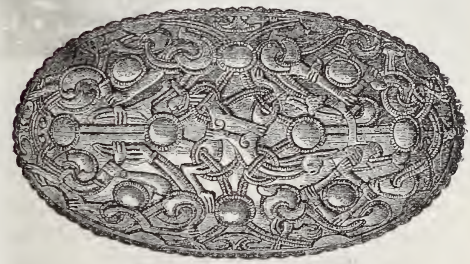


Fig. 13.



Before leaving such Scandinavian types of ornament and their kinship to New Zealand types, I wish to recall the detail in the New Zealand ornament, which we found to be three fingers clasping a body or a curved form. Here is a diagram (Fig. 14) of a Scandinavian clasp, buckle, or fibula, which dates from after the 11th century. In it is a motive of three fingers or claws clasping forms. This is repeated in an orderly way, so that a well-devised pattern is the result. I do not suggest that this coincidence of the three fingers confirms any sort of imitation or trace of inter-influence between the 11th century Scandinavian work and New Zealand work of the 19th century. It seems to demonstrate that gradual developments of pattern-making may be apparently independent of one another, and yet exhibit in a remarkable way an influence of perceptions which in the main have a common similarity and cosmopolitan existence, notwithstanding variations in growth and application.

Fig. 14.



Briefly recapitulating the points in this matter of ornament and pattern-making which I ventured to bring before you, we find, first, that a graphic power in some degree is an attribute of man; next, that this power exhibits itself in rendering imitations of actual things, abstract forms and forms compounded from a mixture of both. These are then repeated to fill a space, and the placing and distribution of them are subject to an appreciation of length and breadth. From this grow repetition and contrast, balance of forms and symmetrical arrangement. The actual expression of patterns varies with the ability of the pattern - maker. If one takes note of such factors as these in a development of ornament and pattern, I think that one learns to perceive the intrinsic charm in works of art, and to become proof against those alluring incidents relating to country and period which have little to do with the cultivation of our respect for skill in performance.

I can but feel sensible that there must be many deficiencies in my attempt to cope with my subject this evening. If any value attaches to my remarks, it has certainly been very much enhanced by the diagrams I have shown. These have been made in Captain Abney's laboratory, and to him both you and I are, I venture to think, equally indebted. For myself I have to thank you for your patient attention.

Next Monday evening my lecture will be about tapestry-making, and I propose then to speak about the special process and its employment in the production of other things than great hangings, as well as about patterns which have been made with it, and their relationship to similar patterns wrought by other means.

[This lecture was illustrated by a series of diagrams thrown upon the screen by means of the electric light].

Miscellaneous.

COLONIAL AND INDIAN EXHIBITION.

TESTIMONIAL TO H.R.H. THE PRINCE OF WALES.

The Committee of the Royal and Executive Commissions named on the 14th July, at the meeting which was held at the residence of Earl Granville, had their first sitting on Tuesday, the 20th July, in the Durbar Hall of the Exhibition. It was resolved :—That Earl Cadogan be requested to act as chairman, and Col. Sir Owen Tudor Burne, K.C.S.I., C.I.E., and Sir Arthur N. Birch, K.C.M.G., as honorary secretaries. Earl Cadogan having taken the chair, it was resolved :—That communications be addressed by the hon. secretaries to the Viceroy of India, the Governor-General of Canada, and the Governors of the various Colonies and Indian Presidencies informing them of the movement. And it was further resolved :—That subscriptions not exceeding the limited amount of £2 2s. each, might be sent to the hon. secretaries, Prince of Wales Testimonial Committee, Bank of England, Western Branch, Burlington-gardens, London, W. ; to the Bank of England, E.C. ; or to any Provincial Branch of the Bank of England. The following noblemen and gentlemen were named as a Sub-Committee to carry out the details of the scheme :—The Earl Cadogan, the Earl of Rosebery, Field-Marshal the Lord Napier of Magdala, G.C.B., G.C.S.I., the Lord Mayor of London, the Right Honourable Sir John Rose, Bart., G.C.M.G., Sir Robert G. W. Herbert, K.C.B.

EXHIBITION PUBLICATIONS.

Special catalogues and hand-books—most of them containing plans and maps—have now been issued by the principal colonies and India. The following list is complete to date :—

I.—Issued by the Royal Commission.

"The Official Catalogue," containing lists of the exhibits in the Exhibition, with introductions to the various sections. Price 1s.

"The Official Guide." Price 3d.

"Her Majesty's Colonies." A series of original papers. Bound in cloth, 5s.

"The Daily Programme." Price 1d.

"The Railway Guide and Route Book." Price 1d.

II.—Issued by the Indian and Colonial Commissions.

India.—"The Journal of Indian Art." Edited by Sir George Birdwood, C.S.I. Price 2s. Monthly.

"Hand-book of the Jeypore Courts," by T. H. Hendley, Surgeon - Major, Honorary Exhibition Officer, Jeypore. Price 1s.

"Permanent Photographs of Madras and Burmese Art-Ware." Price 35s.

"Statistical Atlas of India." Price 10s.

Canada.—"Official Catalogue of the Canadian Section." Price 6d.

"Canada : its History, Productions, and Natural Resources." Prepared under the direction of the Hon. John Carling, Minister of Agriculture, Canada. Price 6d.

New South Wales.—"Official Catalogue of the Exhibits from the Colony." Price 6d.

Victoria.—"Illustrated Hand-book of Victoria." Edited by James Thomson, Secretary to the Commission for Victoria. Price 1s.

"Catalogue of Exhibits in the Victoria Court." Price 6d.

South Australia.—"South Australia: a Sketch of its History and Resources." By John Fairfax Conigrave. Price 6d.

"Official Catalogue of Exhibits."

Queensland.—"Catalogue of the Exhibits in the Queensland Court." Price 6d.

"Queensland: an introductory Essay." By A. J. Boyd. Price 2d.

"Emigration to Queensland: or how to get to that Colony." Price 2d.

"How to settle on the land in the Colony of Queensland." Price 2d.

"The Commerce and Industries of Queensland." By Horace Earle. Price 2d.

"The Pastoral Industry in Queensland." By P. R. Gordon, Chief Inspector of Stock. Price 2d.

"The Charters Towers Gold-fields, Queensland: its rise and progress." Price 2d.

New Zealand.—"Catalogue of the New Zealand Exhibits." Price 6d.

Fiji.—"Handbook to Fiji, and Catalogue of the Exhibits." Price 3d.

Cape of Good Hope.—"History, Products and Resources of the Cape of Good Hope." Edited by John Noble, Clerk of the House of Assembly. Price 1s.

"Catalogue of the Exhibits of the Cape of Good Hope." Price 1s.

Natal.—"Official Handbook." Price 3d.

"Catalogue of Natal Contributions to the Exhibition." Price 3d.

Ceylon.—"Official Handbook and Catalogue of the Ceylon Court." Second edition. Price 6d.

Straits Settlements.—"Notes on Perak; with a Sketch of its Vegetable, Animal, and Mineral Products." Price 3d.

"Notes on the Straits Settlements and Malay States." Price 3d.

British Guiana.—"Special Catalogue of Exhibits in the British Guiana Court." With Introductory Notes by G. H. Hawtayne, C.M.G., F.R.S., Administrator-General, British Guiana. Price 3d.

West Indies.—"Handbook and Catalogue. The West Indies and British Honduras." Cloth, price 2s.

"The Loan Collection of Pictures, Maps, and Historical Relics." Price 1d.

Malta.—"The Malta Court." Price 6d.

Cyprus.—"Handbook to Cyprus, and Catalogue of the Exhibits." Price 3d.

III.—ISSUED WITH THE SANCTION OF THE ROYAL COMMISSION.

"Ye Olde London Streete." Four etchings by Thomas Riley, in a portfolio. Price on drawing paper, 2s.; on India paper, 5s.

"High-Class Cookery Recipes as taught in the National Training School for Cookery." Prepared by Mrs. Charles Clarke, the Lady Superintendent. Cloth, price 2s. 6d.

"Plain Cookery Recipes as taught in the National Training School for Cookery." Prepared by Mrs. Charles Clarke, the Lady Superintendent. Price 1s.

The number of visitors to the Exhibition for the week ending July 31st, was 188,622; making a total since the opening of 2,159,020.

*THE POSITION OF SCIENCE IN COLONIAL EDUCATION.**

The Colonies to which Mr. Carpenter had directed his attention were Canada generally—in South Africa, the Cape of Good Hope, and Natal—West and South Australia, Victoria, New South Wales, Queensland, New Zealand, and Tasmania, the last of which, unfortunately, was not represented at the present Exhibition.

If the term education were used to include not merely scholastic and collegiate training, but also any organisations for drawing out the minds and faculties of the people, a review of the position of science in Colonial education should include all provisions for teaching it in any degree or form in primary, secondary, and high schools of whatever kind, in technological schools with a view to its applications to industrial arts, and in universities or colleges, as well as its promotion by scientific bodies or societies, and the means afforded for its cultivation among adults by museums, botanical, or zoological gardens, public libraries, scientific societies, &c.

In reviewing the whole subject, he had been much struck with the fact that in almost every colony education was a distinct department of the State, under a responsible Minister of Public Instruction, the teachers themselves being, in many instances, civil servants. The advantages of this plan, enabling the minister, as it did, to take a statesmanlike view of the subject as a whole, were well seen in a speech on public education in New Zealand, delivered July 21, 1885, in the House of Representatives, by Hon. Robert Stout, Minister of Education, whose case might be considered a typical one.

Another noteworthy point was the obvious desire, on the part of nearly every colony, to realise Professor Huxley's aspiration for Great Britain, that the State should provide "a ladder reaching from the gutter to the university, along which every child in the three kingdoms shall have the chance of climbing, as far as he is fit to go." In most Colonies, not even excepting South Africa, this appeared to be more or less the case. A State-aided system of scholarships, enabled a boy from the primary schools to pass through the secondary and high schools, colleges, &c., and finally to study at the Colonial University, sometimes also giving him facilities to come to England and take an English University degree, frequently in science. The subjects were considered in the following order in each colony, the colonies themselves being taken in geographical order, beginning with the most westerly. Primary, secondary, and high schools, colleges both special and general, universities, museums, lectures, libraries, scientific societies, and other means of encouraging science among adults.

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* Abstract of a paper read by Wm. Lant Carpenter, B.A., B.Sc., at the Conferences of the Colonial and Indian Exhibition, on Wednesday afternoon, June 23, 1886.

CANADA.

Province of Ontario.—In the primary schools little or no science was taught, but in the high schools a fair amount of physics, chemistry, and botany. The normal schools possessed a splendid collection of appliances for science teaching. The mechanics' institutes had an organised system of science classes throughout the country, specially promoted by Dr. May, for those above school age. The Agricultural College, at Guelph, was world-famed. There was a capital school of practical science, and the University College, Toronto, possessed chemical, physical, and biological laboratories and museums. Various scientific societies did good work.

Province of Quebec (including Montreal).—A Council of Public Instruction, comprising a Catholic and Protestant Committee, controlled the education. A small manual of agriculture was used in primary schools. In McGill University there was a faculty of applied science, and a similar course was given in the Catholic Commercial Academies of Montreal and of Quebec. For entrance to all the professions, an examination must be passed, in which certain science subjects were necessary, as was the case for degrees in "arts" also. The Royal Society of Canada, lately founded, was mainly scientific.

In the maritime provinces of New Brunswick and Nova Scotia, the claims of science to a place in even primary education, and *a fortiori* in the higher branches, were much more recognised than elsewhere in Canada. The primary school course of New Brunswick was almost a perfect model in this respect, and the province spent nearly one-third of its entire revenue on education. In 1885, one-eighth of the entire population of the province received lessons on health, and one-sixth, lessons on useful knowledge (minerals, plant, and animal life, &c.) in the public schools. In both provinces, a university on the basis of that of London crowned the educational edifice, and various natural history societies, musenms, &c., existed in the towns.

SOUTH AFRICA.

Every kind of school was State-aided, and the system was a complete educational ladder, with the kraal schools at the bottom and the University of the Cape of Good Hope (based on that of London) at the top. A high ideal was aimed at, and, theoretically, the elements of natural science were taught in every primary school, even physical geography, for example, in native schools. Practically, however, it appeared that these subjects were too often taught in a very unscientific manner, to judge by the inspector's reports, and the position of science was decidedly unsatisfactory.

AUSTRALASIAN COLONIES.

In every one of these, the State system of education was compulsory and undenominational, public instruction being free in Victoria, Queensland, and New Zealand. The child population of Victoria was better educated than that of any other of the Antipodean Colonies, while New South Wales spent more annually per scholar (£8 2s. 8d.) than any other. The general system pursued was much the same in all, though there were many differences in detail, and special developments in particular colonies, as, for example, technical education in New South Wales.

Western Australia was a very young colony, and only the rudiments of science were taught in a very few schools.

South Australia.—In primary schools, physical geography and object lessons formed part of every course. Secondary schools were partly State-aided and inspected, and chiefly denominational. The educational ladder was very complete, holders of South Australian scholarships going to Europe. This province possessed the only agricultural college on the mainland provinces of Australia. The university gave special degrees in science, and its professors gave free public lectures entirely on science subjects, which were very largely attended. All the scientific societies were more or less connected with the university.

Victoria.—In 1878, a well-considered scheme of education was recommended as the result of a Royal Commission of inquiry into the subject, but owing to want of accessible information, the author could not say how far it had been carried out. In primary schools no science subject except geography was taught, not even object lessons. Secondary education was entirely managed by private persons and proprietary bodies. The university was well organised, its degrees in arts involved some amount scientific knowledge, and it gave degrees in engineering. There were two admirable schools of mines, at Ballarat and Sandhurst, an excellent Industrial and Technological Museum, a Botanic and Zoological Garden, a world-famous Observatory, and eight scientific societies.

Tasmania.—Practically no science was taught in primary schools. All secondary schools were under a Council of Education, which examined for scholarships, &c., holders of which (to the number of ten per year) often proceeded to England to study. Free public scientific lectures were given by the Government chemist. A good museum, public gardens, and a Royal Society, completed the scientific teaching.

New South Wales.—By the Act of 1880, secondary, evening, and high schools, for both sexes, were authorised as State schools. In every public elementary school, object lessons and geography were taught, even in the lowest classes. In the whole educational system, the claims of science were recognised, and a solid foundation laid for the State system of technical education, quite recently developed, chiefly by Mr. E. Combes. The course of study and system was practically that of the London City Guilds Institute, by whose examinations its work would be tested. In Sydney alone, it had 2,634 students (including 500 women), or more than at Finsbury. Last year, 196 popular science lectures had been given in connection with it, attended by 41,000 persons. The university was well organised and endowed, giving special degrees in science and in engineering, and, by its system of junior public examination, it greatly encouraged the pursuit of science. The Observatory, Botanic Gardens, Museum, and various scientific societies, contributed largely to the same end.

Queensland.—In every primary school, a course on "the elementary knowledge of the science of common things" was given. There were numerous scholarships to grammar schools, the education in which was largely influenced and tested by Sydney University. In connection with these there were University Scholarships, the holders of which proceed to Sydney, Melbourne, or England.

New Zealand.—In 1884, three-fourths of all children in primary schools went through a course of object lessons; more than one-half learnt geography; and more than one-fifth, in the three highest standards, received systematic instruction in elementary science. The secondary schools were paying more attention to this subject, specially with a view to technical education so called. In most of the provincial colleges, very good provision was made for the proper teaching of science, many of the professorships being held by men of reputation well known in England. The University was a purely examining body, somewhat on the lines of that of London. So anxious was its Senate to maintain a high standard for its degrees, that in all its degree-examinations the papers were set and the answers revised by English examiners. The author (Mr. Carpenter) was the University agent in England through whom these arrangements were made. In proportion to population, New Zealand had as many students going through a university course as any country in the world, and the influence of this on the progress of science in the colony was most marked.

Reviewing the position of science in Colonial education, then, it would appear that its claims to a place in State-aided primary education were more fully recognised than in the old country, and this, not merely because it was the only foundation upon which a system of technological education could be securely built, but for its value in drawing out the minds of the pupils. As regards the branches by which the time honoured routine of subjects might be most beneficially varied, precedence was almost universally accorded to drawing, and to the objective presentation of the elements of science. In secondary, grammar, and high schools, however, science scarcely occupied a position equal to that in corresponding English schools, but there were many signs of improvement in this respect. In the colleges and universities of the older Colonies, the classical and academic influence was still very strong, while in the newer ones, the claims of scientific education to be put on an equal footing with literary were recognised. Great as had been the progress of public opinion in England during the last few years on the importance of science as an element in education, the author was disposed to consider it greater in the Colonies in the same period. Certainly the development of that opinion to its present point has been much more rapid in the Colonies than at home. There were many voluntary Colonial associations for the promotion of science; and the author concluded his paper by throwing out the suggestion that, if there were grave and practical difficulties in the way of an Imperial federation of the Australasian Colonies, the establishment of an Australasian Association, for the Advancement of Science, somewhat on the lines of the British and American Associations for similar purposes, might not be beyond the reach of practical scientists, and he was strongly of opinion that such a federation would tend to strengthen "the position of science in Colonial education."

BOTANICAL GARDENS AT SAHARUNPUR.

In Mr. J. F. Duthie's "Report on the Progress and Condition of the Government Botanical Gardens at Sahárunpur and Missourie," for the year 1885, a good deal of consideration is given on the cultivation and acclimatisation of useful plants. For some time past Mr. Duthie has paid much attention to the growth of medicinal plants, such as henbane (*Hyoscyamus niger*), taraxacum or dandelion (*Taraxacum denslionis*), so that it now seems crops of henbane and taraxacum are cultivated in the Sahárunpur garden to a large extent, and the indents received from the medical depôts are regularly complied with. Jalap (*Ipomaea purga*), another valuable drug plant, is also being extensively grown. On this head Mr. Duthie says, "it has proved a great success at Aringádh, and I feel confident that we shall be able to meet the wants of the medical department within a year or two. Three hundred tubers were obtained from the Nilghiris, and were planted here soon after the garden was moved to this site. These tubers weighed eight seers, and the yield was 2,150 tubers, weighing one maund and nine seers. A small quantity of seed was also secured. The seeds were sold in February last year, and at the time the report was written (in May) had already produced some good healthy little plants. Cuttings made from the thicker parts of the stem a little above the crowns of the tubers were also tried and proved successful. By these various methods of propagation a large stock of tubers will soon be on hand."

The paper mulberry trees (*Bronssonetea papyrifera*) are reported as doing remarkably well. They were planted only about eighteen months ago, and have already grown to a height of 15 feet. The bark yields one of the most valuable fibres for the manufacture of high-class qualities of paper, and it is well worthy the attention of planters. It will flourish in the poorest of soils, and requires no care beyond occasional waterings during the first year after being planted.

One of the most interesting portions of Mr. Duthie's report, however, is that refering to spider silk. Returning from an expedition to North-Eastern Kumaon, Mr. Duthie says he was much struck with the abundance of spiders' webs in the neighbourhood of Bhim Tál. These webs were unusually large, very strong, and of a beautiful golden colour. They were stretched often two or three deep between the branches of the trees, and on every bush near the shore of the lake, each web containing one or more fine large spiders with black and yellow bodies. After arriving at Sahárunpur, Mr. Duthie says he noticed in one of the numbers of the "Indian Agriculturist" (Oct. 18th, 1884, p. 513), a short article on "Spider Silk," in which the writer, after giving instances of enormous cobwebs which have, from time to time, been observed in various tropical countries, goes on to say, "but the latest addition to our knowledge of spider silk comes from the Paris Ecole Pratique d'Acclimation, a member of which has discovered an African species which spins a strong yellow web, so very like the product of the silkworm as to be scarcely distinguishable from it. This promises to be a fibre of commerce of the future, as after a close investigation, a syndicate of Lyons silk merchants has reported in its favour, and the great difficulty of procuring it in sufficiently large quantities for the loom has been overcome by the fact that there is no difficulty in acclimatising the spider in France." Mr. Duthie obtained from Bhim Tál some of the spiders. The former was submitted to Mr. T. Wardle, and the spiders were forwarded to the Rev. O. P. Cambridge. Mr. Wardle reported that the fibre was evidently of a silken nature, and like silk was loaded with a gummy substance. In a boiling soap solution this gum or varnish dissolves, leaving the fibre apparently pure, and of the nature of fibrin if not identical with it. From careful micro-metric measurements it seems that it has a considerably finer thread or fibre than silk. "The average strength of the spider silk is proportionately greater than that of silk, a single fibre of the spider silk breaking with an average weight of 2¼ drams avordupois, whilst that of China silk breaks at 2⅛ drams."

Mr. Wardle continues, "The most curious property of the fibre is its elasticity, which is considerably greater than that of silk; 30 centimetres of it will stretch to an average length of 36·6 centimetres before breaking; while china silk will only stretch to 34 centimetres. Like silk, this spiders'-web silk is lustrous, and has a round fibre. Its coating of gum, or varnish, is disproportionate to the weight of the silk. On boiling with soap, it lost 7¾ ozs. per pound, that is, 1 lb. of the spider silk discharges 7¾ ozs. of gum. With silk, the proportion is much less, seldom being over 25 to 30 per cent. The fibre apears to dye readily. I believe if it can be obtained in quantity, it might be packed in bales, and sent to England, where it would readily find a market for being carded and spun into silk threads for sewing or weaving purposes. It is difficult to estimate its marketable value; I daresay it would, at any rate, realise 2s. per pound. It is rather dirty, and this would, to some extent detract from its value as compared with silk waste. I have tried to discover how many seripositors this spider has, but beyond noticing under the microscope that the fibres often were in pairs, but not regularly, I am unable to trace whether there are two, as in the ordinary silk, or more."

Regarding the name and habitat of the spider producing this silk, the Rev. O. P. Cambridge identified it as *Nephilengys malabarensis*, Walck, and says it seems to be almost cosmopolitan, he himself having it in his collection from the China Seas, and India, as well as from Australia, Borneo, and West Africa, and it seems to be exceedingly abundant in all its localities. Of the silk, which Mr. Cambridge says is new to him, he comments on its strength and toughness, and says he "should imagine that the fabric which could be made from it would be almost imperishable. Whether it could be spun out from silk collected *en masse* from the spiders' snares, I should doubt; I fancy the only way to get the silk in condition for spinning and weaving would be after some such method as Dr. B. G. Wilder proposed and experimented upon, I believe, successfully some years ago in North America. But the great drawback will always remain, that spiders devour each other, and so cannot be fed and their silk obtained without great trouble and cost."

On the other hand, Mr. Duthie says he has been given to understand that an enormous production of webs is produced by the spider annually, so that there should be no difficulty in obtaining sufficient supplies for undertaking experiments on a large scale. The further development of this spider silk will be watched with interest.

THE FISHERIES OF POMERANIA.

Her Majesty's Consul at Stettin says that during the past twenty years the Prussian Government has manifested a disposition to encourage undertakings for the development of the deep-sea fishery industries. Some years since the Government at its own cost built, fitted out, and manned at a fixed rate of wages, a flotilla of vessels destined for carrying on the fishery in the Baltic; the attempt, however, was not successful, and the vessels were subsequently sold and diverted to other uses. Two later private undertakings from Rügen, with the same object, by means of some fishing cutters purchased in England, and new steamers specially constructed in Stralsund for the purpose, also failed. After these unsuccessful attempts it became evident that the Baltic fishery was not to be carried on in the same manner as the British fishery in the North Sea, that is by trawling. The reasons for this opinion, founded on the statements of the fishermen who were employed, were that the Baltic is not adapted for fishing with heavy floating nets, as on the banks they hit upon stones or refuse and frequently get torn, and in the deeper parts frequently become filled up with dirt and mud to such a degree that either they were already torn while heaving in, or that if actually being drawn on board, before the whole of the net could be got in it was necessary to cut it in order that the foul substance might escape. Another reason was that the fish caught by this process were nearly exclusively flounders, and a species of cod, which do not well repay the labour of pickling on board, although this must be done, because it is not always possible, especially in summer, to gain a port in time to dispose of the fish as fresh fish. Of late years, attention has been directed principally to the herring fishery on the Pomeranian and Rügen coasts by means of smaller and open craft, which has occasionally proved remunerative. It was not, however, so profitable as it might have been, because the fishermen, owing to the construction of their boats, could not keep the sea in stormy weather, and frequently suffered loss by being obliged to abandon their nets in order to reach the coast or harbour speedily. It was on these grounds that the Government, in order to promote the deep-sea fishery on the coasts of Lower Pomerania, granted in the years 1882 and 1883 support and money advances, free of interest, to several fishery companies and societies, and these purchased boats and nets from the fishermen of the south of Sweden. The Swedish fishermen ply their occupation over the whole of the Baltic with seaworthy boats which have been proved to be serviceable in every respect, and for the last ten years they have frequented the harbours of Lower Pomerania to dispose of their fish. The amounts realised by them on herrings and salmon soon attracted the attention of the fishermen of these places, and by the aid of the guaranteed State assistance eleven companies at Colbergermünde were enabled to furnish themselves with Swedish fishing boats and nets, and thus to prosecute the herring fishery with proportionally favourable results. From 150 to 200 *wall* (a *wall* being equivalent to four score) of herrings are frequently taken in a night on the Pomeranian coasts, and on the 8th September, 1884, one boat brought into Stolpmünde Harbour a take of 400 *wall* which realised about £18. The herring fishery on the Pomeranian coasts is carried on during the months of April and May, and September and October, at which time the herring shoals traverse the south of the Baltic at from two to eight nautical miles from the coast. The most abundant takes on the Pomeranian coasts were made in 1884 off Jershöft and Rügenwalde. Salmon are fished for during the month of May only, at which time the fishermen carry on their operations with salmon and herring nets near the coast. Line fishing for salmon is practised within a distance of 25 nautical miles from the coast from November to March.

ABYSSINIAN ECONOMIC PLANTS.

Among the vegetable articles of diet of the Abyssinians, the first place is taken by *teff* (*Poa abyssinica*), a herbaceous plant, whose grains are as small as a pin's head; the meal from this forms the bread in general use. A much inferior black bread used by the poor is made from a kind of millet called *tocusso* (*Eleusine Tocusso*), frequenting the low grounds. In addition the roasted seed of the flax plant (*Linum usitatissimum*) is sometimes eaten, as it was by the ancient Romans and Greeks. Another admired vegetable is the flower stalk of the local plantain, called *ensete* (*Musa Ensete*), the fruit of which is dry and unfit for eating. The stem is cooked with milk and butter. It is cut off just above the rootlets, and about two feet high; if old, the green outer coat is peeled off till the white interior shows. It is as tender as a well cooked turnip, with a flavour like the best new bread somewhat underdone. It is an excellent dish, nourishing, wholesome, and digestible. From meal cakes a fermented drink called *bousa* is made.

The coffee grown in Abyssinia is principally sent to Djedda and Upper Egypt; though not of first rate quality, it possesses a special aroma, and is sold at the rate of 16 dollars per *cantaro* of 113 *rottoli* (say 37s. per cwt.).

The women of Gurage make mats of the leaves o the *ensete*. The *ecca* of the Abyssinians, a species of asclepiad, produces a tough fibre, used in making cordage and tissues on the Red Sea littoral. The bark of *Calotropis gigantea* affords excellent fibre used for various purposes. The tender leaves newly pulled from the stipa of the *doum* palm are woven into all kinds of matting and basket ware. The powdered seed of a large tree called *berebera* (*Milettia ferruginea*) is thrown into the water to stupefy fish and facilitate their capture. The native dress consists of a large folding mantle and close-fitting drawers. The houses are rude conical structures covered with thatch.

Among the local products figuring in the exports are:—Calves' hides, salted and sun dried; beeswax, chiefly from Gedaref; ivory; tamarinds; ostrich feathers; gutta-percha, from Kassala; gum arabic; mother-of-pearl; leopard skins, about 1,000 annually to India; musk, contained in bulls' horns, to the number of 200 to 300 a year; honey; and tobacco, chiefly from Sanaaid.

GOLD WASHING IN ITALY.

Washing for gold has been practised from time immemorial in Piedmont, in the beds of some of the torrents which flow from the Alps to the Po. According to Pliny and other ancient writers upwards of 5,000 persons were engaged in this occupation at one time. In modern times, however, it has only been practised on a small scale, and principally in the beds of the torrents Orco, Malene, Dora Baltea, and Ticino.

Of late years the existence of these auriferous sands has been more fully investigated, and have been found to extend at the foot of the Alps from Legin and St. Maurizo on the West to the Dora Baltea on the East, and bounded on the South by the Po, covering an area of 100,000 hectares, or about 250,000 acres. The depth of this gold-bearing deposit varies from 5 to 8 metres, and although the amount of gold these sands contained connot be said to have been ascertained with any degree of accuracy, there appears to be every reason to believe that the estimate of 0·40 grams per cubic metre is not an exaggerated one (0·01286 Troy ounces (0·2572 dwts.).

A company, the "Società dei Giacimenti Auriferi di Piemonte," have recently commenced operations in the bed of the torrent Orco, near San Benigno, and a few weeks ago inaugurated a powerful steam dredger, named the "Regina Marghousa," which has been constructed especially for the excavation and washing of these sands, by M. Perrin, of Lyons; it is of 50 horse-power, and is capable of raising from 2,000 to 2,500 cubic metres of stuff per day of twenty-two hours. The buckets are twenty-two in number, and are capable of excavation to a maximum depth of 8 metres.

General Notes.

Institution of Mechanical Engineers.—The summer meeting of the Institution will be held in London, on Tuesday morning, the 17th of August, and Wednesday morning, the 18th of August, at 25, Great George-street, Westminster.

Melbourne International Exhibition.—The trustees of the Melbourne Exhibition building are desirous of establishing in that City a loan collection of works of art, and they will be very glad to receive offers to lend pictures, statuary, or other objects of art, from artists or from the owners of such works. The building in which the collection will be shown is stated to be the largest in all the colonies; its dome ranks as one of the largest in the world; it is national property. The trustees consist of four members of the Legislature, elected permanently, by Act of Parliament, one Alderman elected by the Corporation, and the Mayor of the City of Melbourne during his tenure of office.

Fresh Water Fisheries of Italy. — A decree relating to the establishment of commissions to be charged with the control of all the lake and river fisheries in Italy, was recently published in the *Gazetta Ufficiale*, of Rome. Part of the duty of these commissions, which will be appointed in various districts throughout the kingdom, will be to consider and propose any new laws or regulations that may be found necessary from time to time. To collect statistical data for a return to be published annually respecting the fresh water fisheries. To advise the Government, provinces, and communes, upon all matters appertaining either directly or indirectly to this industry. To encourage the introduction of improvements in the methods adopted hitherto in fishing, and in the various industries connected with it. To popularise a knowledge of all relating to the habits, food, and diffusion of the most important and useful kinds of fresh water fish. To aid the Government in re-stocking the lakes and rivers. Each commission is to consist of five members, of whom one, a zoologist, will be nominated by royal decree; whilst the other members, who are to be appointed for three years, will be eligible for re-election.

Drainage of the Lake Kopais.—A telegram from Thebes announces the inauguration of the Kopaïs canal which has lately been constructed for giving an outlet to the lake of the same name. The drainage of this lake is one of the most important works for the reclamation of land that has been carried out of late years, and may be compared to that of the lake of Fucino, in Italy, which was successfully completed by Prince Torlonia some time since. The basin of this lake receives annually a no less quantity than 300 millions of cubic metres (10,595 cubic feet) of water, and the large extent of land thus constantly submerged, renders it unfit for cultivation, and the stagnant water made the whole district a most unhealthy one, as it produced pestilential exhalations during the summer months, which infected and poisoned the air for miles around. These marshes, it is expected, will soon become a most fertile district, and the waters will be stored and utilised in dry seasons for the irrigation of about 7,000 hectares (17,298 acres) of land, and the canal will furnish abundant water power, which can be eventually utilised for industrial purposes. The total area of land drained by the canal is about 25,000 hectares (61,778 acres).

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Proceedings of the Society.

CANTOR LECTURES.

THE ARTS OF TAPESTRY-MAKING AND EMBROIDERY.

By Alan S. Cole.

Lecture II.—Delivered May 12th, 1886.

[The right of reproducing these lectures is reserved.]

My lecture this evening is to be upon tapestry-making. The word tapestry has grown to be used in two senses, from which a good deal of confusion and some uncertainties have ensued. From a general and non-technical point of view, the word tapestry has been used to indicate any sort of decorated hanging. Thus early mentions of tapestry have been accepted as proofs positive that the special process which is now identified with tapestry-making was in question. But this assumption is not, I believe, correct. The special and technical meaning of the word "tapestry," in its indication of a peculiar process, will, I hope, become clear as the lecture proceeds.

Various books upon tapestries and textiles—and one or two have been lately published in France of remarkable completeness—contain abundant quotations from old writings to prove the use of decorated textile fabrics for hangings and curtains, at the times of the Egyptians, the Assyrians, the Greeks and Romans. And as this particular branch of the investigation seems to have been pretty fully dealt with, I do not propose to further follow it. It may probably be taken as certain that actual specimens are not likely to be forthcoming of the curtains with cherubs' heads, used for the Tabernacle of the Ark, of the cloths adorned with animals and episodes which are mentioned in the Iliad, or of the hangings decorated with illustrations of Greek myths and victories which Apollonius of Tyana is said to have seen at Babylon. Whether these were embroideries, or woven and painted cloths, it is impossible to say. It is, however, I think, more than probable that they were not made as tapestries, say from the 13th century, have been.

Remains of other textiles, mummy cloths, portions of costumes used in ancient Egypt, and woollen stuff of the Bronze Age in Scandinavia prior to the Christian era, have been discovered, and their methods of production duly verified. The majority, if not all, of such witnesses to the antiquity of well-wrought weavings and sorts of embroidery, have been preserved for centuries in subterranean burial places in coffins of wood and stone, whence they have been exhumed by the modern explorer; but hangings and large pieces of stuff to decorate buildings have not, apparently, been so deposited as to insure their existence for long periods. Other causes, too, have helped to efface traces which would be of value in demonstrating an evolution in the use of decorative hangings. The depredations of fanatical iconoclasts, not only in Europe, but also in continents like India, are too well known to require now more than a note. The effects of earlier sectarian repugnance for decorative works may be inferred from such letters as St. Epiphanius, Bishop of Salamis, wrote to John, Bishop of Jerusalem, in the 4th century. Although this letter has often been quoted, I venture to give an extract from it. The bishop writes:—

> "On my journey through Anablata, a village in Palestine, I found a curtain at the door of the church, on which was painted a figure of Christ, or some saint, I forget which. As I saw it was the image of a man, which is against the command of the Scriptures, I tore it down, and gave it to the church authorities with the advice to use it as a winding-sheet for the next poor person who might have occasion for one, and bury it."

Speculations, however, as to the probable recovery of this curtain, or any earlier decorated wall-hanging or curtain, need not perhaps occupy our attention.

The question what then is tapestry seems to me to require an early answer. To the French word *tapisserie*, an off-shoot of *tapis* (carpet) we are no doubt mainly indebted for one word, in which, however, we have a second "t" deriving it from the Latin word *tapètum*, a source common both to French and English words. As early as 1250, French regulations of the artisans of Paris contain mention of *tapissier sarrazinois* and *tapissier nostrez*—and sixty years later, "tapicers" are named in ordinances concerning such craftsmen established in London. Last Monday I suggested that tapestry-making was more like certain forms of carpet-making than any other special branch of textile manufacture. It is possible that the 13th and 14th century *tapissiers* and *tapicers* were men engaged in producing coverings and stuffs for use as carpets and hangings—woven either in the ordinary way, or done according to the special processes of carpet and tapestry-making. Although there is scarcely any evidence to show that tapestry hangings, in the technical sense, were made in Europe before the 12th century—the actual process which came to be identified with such articles was well known in the Saracenic countries of that and earlier times. It would appear that this process was used in respect of trimmings to dresses. On the other hand, Tartar and Turcoman people appear to have used an identical process for making carpets and such like. I do not think anyone has been able to decide the question as to the actual difference in craft between the *tapissier sarrazinois* and the *tapissier nostrez*. The latter is thought to have produced some home manufacture as distinct from an imitation of Saracenic manufacture. However this may be, I will now submit certain diagrams by which I hope to show the difference in process between weaving and tapestry and carpet-making.

Woven fabrics made by hand are produced, as this diagram indicates, by passing a shuttle charged with thread, thrown across and in between alternate threads stretched in two ranks. The two ranks can be raised above or brought beneath one another by two frames, each of which operates in respect of one rank of threads only. These frames are moved by pedals. When the shuttle with its thread has been thrown across the width of the two ranks of warp, a comblike instrument is brought against the interweaving thus made, so as to compact the thread of the shuttle between those of the warp. The textile as made is wound round a cylinder, and the weft and the warp threads are equally visible on both sides of the fabric.

Now for carpet-making by hand, a stretched rank of warp threads is also necessary. But these warp threads plays no visible part in the face of the carpet. They are covered round with weft threads. Instead of a shuttle with a weft, as in weaving, you use various sets of thread, which you loop, knot, and intertwist on the warp threads. In making carpets with a pile, you cut the ends of the threads which have been knotted on to the warp. From above these knotted threads, and across and in between the warp, a stout thread is thrown. This is pressed down with a comb, so as to compact the whole fabric. A fresh series of knottings is then made, and the above-named operations repeated. The weaving diagram showed that the warp-threads lay in a horizontal position. In carpet-making the warp-threads are usually in an upright position. Here I show a sketch of some Indian workmen making a carpet upon upright warp-threads. On an upper cord, above the heads of the workmen sitting in front of the warp, are hung bunches of thread, which may be of silk, wool, goats, or other hair. The sticks within easy reach of the workmen are attached to a set of strings which are fastened to alternate warp-threads. By moving the sticks, half of the warp threads can be pulled forward so as to divide the warp into two ranks, between which the cord may be thrown above each series of knottings. To the left of one worker is a small pronged instrument, like a comb with a long handle. This is used for pressing down the work. To the right of the other workman is a pair of scissors, with which he clips the ends of the knotted threads and trims the piled surface of the fabric. This method and apparatus has probably been in use for many centuries in the East. And rough and ready as they appear to be, highly finished carpets with one side of close sheeny pile, lovely in pattern, colour, and texture, have been made with them.

But there is another closely-allied process for making carpets and hangings. This is one in which no stout cord is thrown across and in between the warp; no scissors to cut the ends of knotted weft-threads are used, and no pile is produced. Both sides of the textile so made are often alike. This process requires that the variously-coloured wefts shall be intertwisted between groups of the warp-threads. In this respect it is almost identical with that particular process which is known as tapestry-making; tapestries, however, are finished for display on one side only.

By the help of a few plates which have

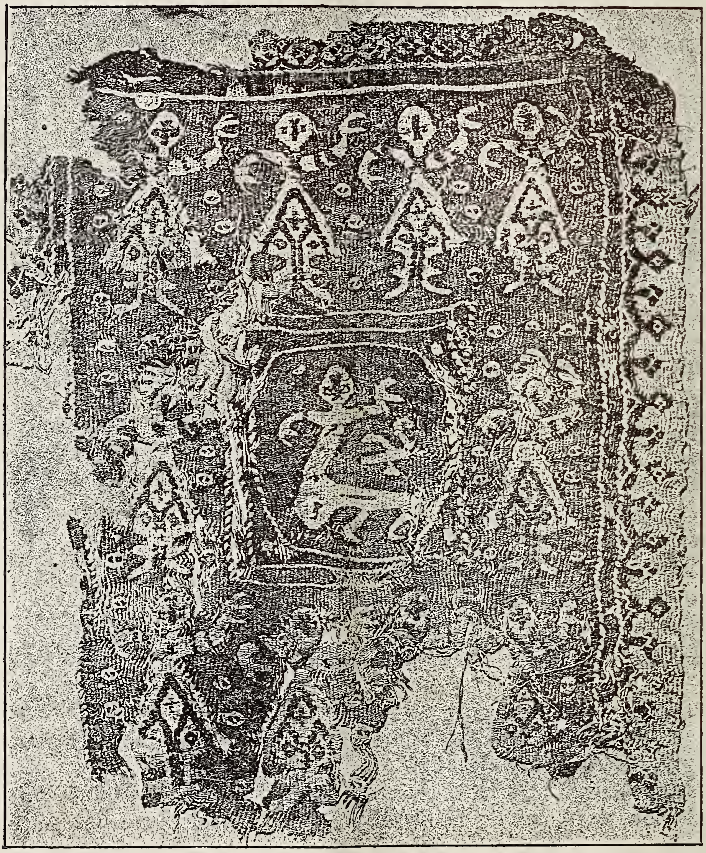
been photographed from a standard French Dictionary of Manufactures, published in the last century, I hope to present you with the leading features of tapestry-making. My first illustration gives a considerable framework, containing a wide range of warp-threads, upon the lower portion of which is seen the face of the tapestry, with completed parts of the design. The workman is at the back of these warp-threads, and his design is placed upon the board, leaning outwards, in front; this he sees through the warp-threads. Here he is at work. The numerous pegs or slays are wound round with coloured threads; the attachments of strings, some of which he is pulling, operate upon the warp-threads. He can thus pick out and pull forward the particular warp-threads between which he has to intertwist the thread of a particular slay. In the pile carpet-making processes slays are not used. Another diagram gives us an idea of how the comb is used.

Tapestries are made not only upon vertical threads, in the manner roughly described, but also upon horizontal threads. These two illustrations indicate the use of the process in its connection with horizontally ranged threads. In the upper one we have the worker intertwisting his slay of weft-threads, whilst in the lower he is using the comb to compress his work. Tapestries made upon vertical warps are termed high warp, or *haute lisse* tapestries. Those made on horizontal warp are called low warp, or *basse lisse.* But the results of both methods are virtually identical, so that it is almost impossible to detect any peculiarity which shall distinguish the *haute lisse* tapestries from those of the *basse lisse.* In weaving, you may have, as I mentioned, the warps either vertical or horizontal; and this is not unimportant in regard to the conclusions which some inquirers have arrived at, that the mention of high and low warp, *haute* and *basse lisse,* must imply one or the other of the tapestry-making processes.

Sir Gardner Wilkinson gives a drawing from sculptures 3000 B.C., of Egyptians at work upon a small high warp frame, and the arrangements for pulling forward the vertical warp-threads establish an idea that a tapestry-making process is being used by them. This process is, as I have said, of great antiquity, and of wide-spread employment. As to its antiquity, I have a specimen, Fig. 1 (p. 950), now preserved at the British Museum. It was exhumed from some tomb near Sakkarah, an Arab village near Memphis. I believe that the late Dr. Birch considered that it was pre-Christian in date, possibly belonging to the period of Greek colonisations in Egypt. It is possible that the corselet mentioned by Herodotus as having been captured by the Samians, in the course of its transit from Amasis, King of Egypt, who sent it as a present to the Lacedemonians, was ornamented with such work as that now before us. The date of that corselet was probably about 530 B.C. Herodotus describes it as made of linen, "with many figures of animals inwrought and adorned with gold and cotton wool, and on this account," he says, "each of its threads make it worthy of admiration. For though it is fine, it contains 360 threads, all distinct." These 360 threads might be the warp-threads. In the specimen before us there are, in the width of 8½ inches, upwards of 184 warp-threads, and the number of crossing wefts on each warp-thread of 11 inches long, is 600. Possibly that portion of the linen corselet which excited the admiration of Herodotus may have been a panel of ornamental work about 17 inches in width, which would not be too large to serve on the front of the corselet. It might, indeed, have been a sort of ephod—like the linen ephod, perhaps, which David wore when he danced with all his might. I make these suggestions with much deference, relying very much upon what I have gathered to be the opinion of the late Dr. Birch as to the date of the actual specimen before us. He has described it as a rectangular fragment. In the centre is a square of green ground, upon which appears in white with red outline, blue eyes and armlets, a nude figure of Aphrodite, in front of whom is a swan flying. This compartment is about 3½ inches square. Round it is a broad border, on which in red, blue, and white are ten draped female figures standing—the left hand and arm of each is raised—whilst the right arm hangs pendent. The four figures on the upper and the four on the lower part of this border are full face; the figures at each of the other parts appear to wear head dresses and face to the left. The drapery of the figures exhibits on the skirts a pattern of three diamonds, in one of which is a cross in the other two are circles. The ground above these figures is strewn with blue and white spots or flowers. The whole rectangular fragment has been surrounded with blue and red border between white lines. The outer edging of all is a rude rendering of the bud and blossom device. As may have been noticed, the drawing of the various forms is quite archaic or primitive.

It is evidently done by someone possessing but little skill in realising and depicting the subject. Similar quality of drawing is to be seen in other relics of this class of work, which have recently been rescued from tombs, probably of Christians of the Coptic sect. In such, the figures pourtrayed wear *nimbi* like those of Christian saints. Specimens of these robe ornaments have recently been acquired for the South Kensington Museum from Egypt. From some parts the coloured threads have completely disappeared, leaving, however, the warp-threads, thus furnishing a key to the manner in which the work was done. It is probable that small slays were employed, the warp-threads being stretched in a handy frame of some sort. When the work was finished, it was stitched to the coarse linen robe. This tapestry-making process for making costume ornament, upon a small scale, has not, I believe, been used in Europe. It is known, however, to Peruvians and natives of Borneo. Specimens of tapestry-making, in which the weft is silk throughout, are made, on a small scale, in the public school for females at Kiyoto Fu, in Japan. The Japanese seem to regard them as displaying a new sort of work which they have lately invented, and accordingly named Tsu-zu-re-ori. But this specimen, which is about a foot high, shows that the process is identical with tapestry-making as already described. I have little doubt that the Japanese adapter derived his idea of the method, perhaps, from some bit of European tapestry, or from a Turcoman, Central Asiatic, or Mon-

Fig. 1.



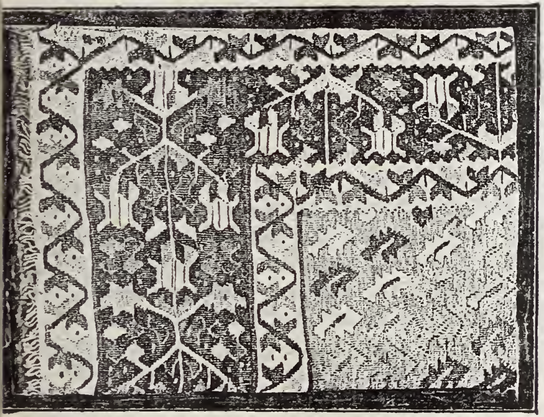
Panel of Tapestry-Weaving for the decoration of a Dress from Sakkarah, near Memphis; Græco-Egyptian, 2nd or 3rd century B C. (?)

golian carpet, produced in this way (Fig. 2). So much, then, for the process of tapestry-making and some of the peculiar uses to which it has been put.

Its celebrity, however, in Europe, arises from its use in connection with hangings, the larger quantity of which has been made with strong warp-threads or strings, usually over-worked with worsted, sometimes with worsted and silk. In such form we seem to have no data upon which to found a statement that this class of work appears in Europe before the 13th century. But at this date we get indications of the special application of the process to the production of stuffs to be used as hangings, and such like.

Of hangings, without regard to their particular make, we have representations such as this diagram furnishes. It is engraved in M. Muntz's excellent work on "Tapestries," aad displays a corridor of the Emperor Theodoric's palace at Ravenna, the seat of the later Roman Government. The curtains, looped under the arcades, were probably of ordinary woven material, far thinner and lighter in texture than tapestry-made hangings. The ornament upon them may have been painted, embroidered, or woven into them. It may, indeed, have been done by the tapestry process on the small scale of the Egypto-Coptic specimens; but of this we know nothing with certainty.

FIG. 2.



Corner of a Curtain or Carpet or Tapestry Weaving; Turkoman manufacture.

The diagram, however, may give us ground to surmise that the influence of Rome and her Oriental connections, which had been protracted through centuries, affected the adornment of palaces long before the times of Theodoric. And as the organisation of the Christian Church, with its ramifications in the East, spread itself about Europe, fashion, in the use of decorated textiles, was widely disseminated. One or two instances will suffice. Withlaf, a king of Mercia, in 833, presented a cloth of gold displaying the destruction of Troy to the Convent of Croyland in England; and in 992 Abbot Egelric (the second of that name) gave the same establishment two large foot cloths, woven with lions, to be laid before the high altar on great festivals. Possibly these articles were of wool. Now from the first century "coarse wool, woven in Belgium, found a greedy market in Rome," according to Signor L. Brentano, and the industry was extensively practised during succeeding centuries by the noted weavers of Flanders and Brabant. We have little to guide us as to the sorts of patterns which may have been wrought in these fabrics, but I hope I shall not be charged with overtaxing your credulity if I suggest that perhaps in the 10th and 11th centuries some such patterns of lions like this specimen may have been used. This character of pattern appears also in more delicate textiles, which are generally thought to have emanated from Greece and Sicily between the 10th and 13th centuries.

Besides indicating conditions consequent upon the desire of the rich and powerful to be supplied with the best obtainable articles produced by artistic man, history also points to the effect which has followed upon the efforts of handicraftsmen from the earliest of times, to perpetuate a supply of wonder-stirring works, the sight of which gave birth and life to demand. Commerce in such works ensued. To instance early commerce, I need not go so far back as the almost prehistoric amber trade of the Phœnicians with North Europeans; but as the period when the patterned stuffs of which I last spoke belongs to years between the 9th and 13th centuries, of which we are generally considered to know but little, I thought I might place before you a few items illustrative of the spread of commerce, the specialising of crafts in the formation of craft gilds, and the establishment of organised factories about that time.

The constitution of craft gilds is said to have been adopted from the more ancient religious gilds. The late Mr. Toulmin Smith's book on "English Gilds" gives much information about them. And, as germane to our subject, it is interesting to read that "foremost amongst the free handicraftsmen of the Germanic States, for some centuries before the 11th century, were the weavers." They formed a kind of middle class between the patricians and the bond craftsmen. "Whilst the other craftsmen worked to supply mere local demands, the weavers' manufactures found markets in the most distant countries, which fact naturally invested them with greater personal importance." Accordingly, in all the manufacturing countries of that time, in England, Flanders, Brabant, as well as in the Rhenish towns, the most ancient gilds were those of the weavers. The Gild of London Weavers was chartered by Henry I., and so was that of the Oxford weavers. In Germany the Woolweavers' Gild of Cologne arose as early as the 11th century. At Spire, the Gild of the Woolweavers existed at the beginning of the 12th century. At Mayence, the weavers are mentioned as early as 1099. Corresponding organisations in the East—in Persia, in Syria, and Byzantium certainly existed at these times and earlier. Apart from the indications one finds in the Bible, dating from hundreds of years before Christ, the fact that splendid textiles were made in Syria particularly is brought out in Washington Irving's "Successors of Mahomet"—and, of course, by Gibbon previously. The Saracens or Moslems at the beginning of Mohammedanism levied from the towns of their early conquests in Syria, tribute which in great measure consisted of fine textiles. Damascus, famous in the 7th century for its silk weaving, was taken by the Saracens. These conquerors allowed the supposed daughter of the Roman Emperor Heraclius, who was married to Thomas, a noble Greek in Damascus, to leave, taking with her three hundred boxes containing costly silks and cloths of gold. Nevertheless much similar booty was left for the Moslems when they entered and sacked the town.

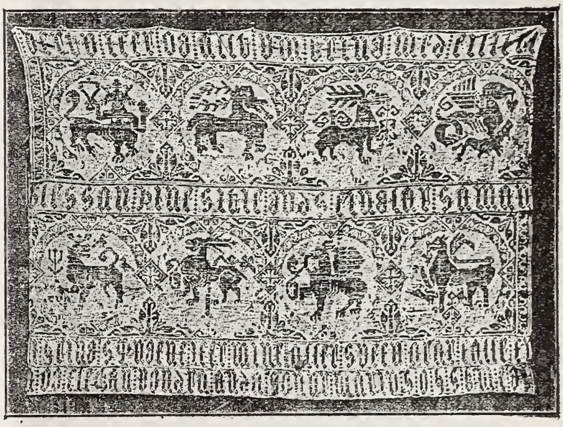
How far the Persians, who were subsequently vanquished by the Saracens, had encouraged costly productions, may be inferred from the detailed description of a large and sumptuous carpet used in the palace of the king, Yezdegird. This carpet was of silk. In design, —suggestive of Vathek's mountain paradise—it represented a parterre of flowers embroidered in their natural colours, and overlaid with jewels; the fountains playing amongst the flowers were wrought with diamonds and sapphires, to represent the sparkling waters. The value of the whole was beyond calculation. The carpet was taken from the palace at Madayn, and brought to Caliph Omar at Medina. The caliph ordered it to be cut up and a piece given to each of his chiefs, one of whom sold his portion for eight thousand dirhems of silver. It was at this time that the port of Amalfi in Southern Italy grew to importance. According to Gibbon, it was for 300 years a principal centre for supplying the Western world with the manufactures of the East. Before the 8th century, even, we get an idea of the wide scope of Oriental commercial relations with France, in the mention of certain Greek and Syrian merchants who established a centre, for their operations in the silk trade, at Paris during the 6th century. That they gained popularity is attested by one of them becoming Bishop of Paris.

A mention of the establishment of silk-weaving looms in Sicily may illustrate my reference to organised factories. In the 11th century, the Normans came down from the north of France to break the power of the Saracens, which then reached over Southern Italy and Sicily. The Norman expedition went to Greece. Under the domination of chiefs like Robert and Roger Guiscard, the manufacture and weaving of silk were introduced into Palermo. Gibbon relates that, after sacking Corinth, Athens, and Thebes, Count Roger despatched his lieutenants for Sicily "with a captive train of weavers and artificers of both sexes. A stately edifice in the Palace of Palermo was erected for the use of the industrious colony; and the art was propagated by their children and disciples to satisfy the increasing demand of the Western world." This establishment is mentioned by contemporary writers as the Hotel des Tiraz. "The decay of the looms in Sicily may be described to the troubles of the island and the competition of the Italian cities."

From these foregoing indications we may perceive that, at the 8th century, in Europe there was considerable activity in producing articles of artistic manufacture cognate, in their use at least, to that of tapestry-made work. Now the earliest piece of hanging made by the method corresponding with that of the old Egyptian costume trimming we looked at dates probably from the 12th or 13th century. It is comparatively narrow, and was of some length. This character of shape is distinctive in hangings of lighter stuff, as well as with early tapestry hangings. Larger and squarer tapestries are of later date. There is much discussion as to where this early piece of tapestry, a portion of which I show, was made. Some have thought it was made in Syria, others in Germany, and this latter country, I think, establishes a better claim to it, though, in some respects, France might prefer an equally strong claim to having produced it. The larger portion of it is preserved in the museum at Lyons. Another piece is in the museum at Nuremburg. And a bit of the border is in the South Kensington Museum. Here is a photograph of this bit, in which the twisting of the threads may be clearly followed. The tapestry is made of woollen threads, chiefly greens and blues, twisted around stout flax strings or warps. When intact, the whole piece belonged to the Church of St. Gereon at Cologne. The scheme of the pattern consisted of a series of repeated ornamental circular bands, within which are figured chimerical birds and beasts. This device occurs in Oriental ornament, and is frequent in ivory carvings, metal works, and embroideries of the 12th and 13th centuries. But here is an earlier example of the principal motive in the pattern. This gold vase is considered to be Scythic, Perso-Roman, or Græco-Asiatic work of the 4th century A.D. A scheme of pattern in which the repeating circular bands surrounding birds and creatures are used, may also be noticed in the chasuble of Pope Boniface VIII. This is a photograph of the back of it. The chasuble is entered in the inventory of the Pope's possessions, dated 1294. This character of ornament is vaguely called Oriental and Byzantine. But imitations of it have been produced far and wide. We may find it in modern Japanese weavings, and what may strike us as even more remarkable, we have it in Icelandic embroidery which dates from the 16th century. Through the kindness of Mr. William Morris, I am able to show you a diagram of the Icelandic specimen (Fig. 3). This is a coarse linen hanging composed of two bands of linen joined together. It is embroidered with wools in a running or darning stitch. The scheme of repeated circles inclosing chimerical creatures plays as we see the principal part of its pattern. The indications of the circles are indistinct, though sufficient for the purpose of tracing the use of this character of design. The legends are in a sort of Gothic black letter. Kindred pattern is to be seen in weavings of the 12th or 13th century from Sicily or Italy. So much, then, for this particular motive and pattern, the modifications of which could furnish matter enough for a single lecture.

Returning now to the length and narrow width of the early tapestries, it is to be noted that they were used as frieze-like decorations or bands to be hung along the walls of churches and buildings. A remarkable instance of such long hangings is given us in the famous linen band embroidered in wools, with over seventy different scenes connected with the Norman conquest. Mr. Fowke's book on this precious relic of 11th century art exhausts all that has to be said about it. The portion I show displays a part of the king's palace; then comes a view of an interior, where Edward the Confessor, seated, is in coversation with two personages, of whom one—the taller one at the back with the moustache—is probably Harold. Then we have a troup of horsemen led by Harold, upon whose left hand is a hawk. Harold is riding, as the legend tells us, to Bosham. In front of the cavalcade are hounds. The building they approach is a church, with two men kneeling at its entrance. Along the border we have repeated pairs of beasts and birds, reminding us of the like devices which occurred in the roundels previously seen. This long linen hanging—measuring some 230 feet by 20 inches—is celebrated as the Bayeux Tapestry. But the term tapestry applies solely to its use, and not, of course, to its make, which, as has been said, is of embroidery. That it may have been wrought at Bayeux is possible. The earliest mention of it occurs, I

Fig. 3.



Icelandic Embroidery in Worsted upon Linen ; probably of the 16th century.

believe, in an inventory of the contents of Bayeux Cathedral, dated 1476, where it is accurately described as a "tente très longue et etroite a broderie." In the 16th century it is again entered as a *toile à broderie;* but the name *tapisserie* has been given to it, giving rise, in consequence, to occasional misapprehension as to its technical character.

The next few bits of real tapestry I have to show, further demonstrate the long and narrow shape of early tapestries which survived into the times when larger and squarer specimens were produced. Here is a strip of the early 15th century tapestry work, made perhaps in South Germany. It represents the wooing of a princess by two suitors; comparatively rude in drawing—it must have been rich in colour. The threads in it are of wool, but small portions are also worked with gold thread—now almost black. A conventional treatment of renderingis marked, in the use of black threads out-lining many of the details — a characteristic of many early tapestry designs. Scrolls with legends upon this are introduced amongst the various groups of figures. This feature constantly recurs in tapestry designs of the 14th century. Examples of it are in the Church of Saint Laurent, at Nuremberg, and in the National Museum, at Munich. Here again we have a frieze-like tapestry, in which is figured the admission of a young lady into a sisterhood.

Tapestries such as these, then, form the connecting link, as it were, between the circular band and animal pattern of the Cologne 12th century tapestry, and the patterns of figure subjects depicted from the 14th century onwards. The tapestries of early times, *i e.*, 13th and 14th centuries, are thought to have been almost exclusively made in small frames, in which the ranks of warp were stretched horizontally—and this, as I have previously mentioned, is known as low warp, or *basse lisse* process. There seems, however, no particularly good reason why upright frames with vertical warp *(haute lisse)* should not have been in use concurrently. But this is a point of anxious dispute amongst those to whom it is of importance. One fact may be noticed here, and that is that in the evolution of the method of tapestry-making, the production of larger pieces than those we have seen as types of early European tapestry, necessitated the use of wider and better constructed high or low warp frames. In these larger frames designs of correspondingly increased size were wrought in tapestry.

From the 13th century, the decoration of walls in Italy and the South was reviving and becoming wide-spread in the use of fresco-painting. And to some extent one traces in the tapestries of the northern and more weather-wearing countries a companion fashion to that of the southern frescos. There can, however, be no doubt that, without the revival of painting in Italy and its necessary influence, painting in the North would not of itself have put forth the great figure-designs for tapestries, such as began to appear in the 14th century. From this period onwards, we have frequent indications and evidences of notable bodies of craftsmen known as "tapissiers," and in England as "tapicers." In the first instance, they may not have particularly identified themselves with the tapestry-making process. Their business was always in connection with stuffs like carpets and hangings, which were originally woven. Subsequently some were made according to the special process, by which the workman was able to produce a wider range of effects. I believe that the number of colours of the earlier tapestries was restricted in a way which reminds one of the limited number of tones at the disposal of the water-colour painter a hundred years ago. And it is not until the tapestry-making craft is well established, that the employment of a more generous scheme of colours occurs. This has developed in such a way that it is a boast now at the famous Gobelins factory that they have upwards of 14,400 tones of colours in dyes for threads. But 300 years before the establishment of the Gobelins factory, under the patronage of Henry IV., the peculiar process and its practice had been encouraged very considerably by the Dukes of Burgundy. The far smaller number of colours available for use engendered a simpler rendering of designs than that which marks the tapestries of late 16th and succeeding centuries. Although the Dukes of Burgundy, early in the 14th century, are historically conspicuous as promoters of tapestry-making, it should not be inferred that the manufacture secluded itself solely under their auspices. Amongst the mysteries of craftsmen there are records of some applying to "tapicers" in England at this time. These workmen were influenced by works possibly more splendid than they themselves were accustomed to make. The French Sovereign presented handsome tapestries, made in Paris and Angers, to Edward II. and Edward III., and no doubt many other foreign specimens were imported into England.

Monsieur Guiffrey has cited some interesting facts concerning a prominent tapestry worker of whom he has found records dating from the 14th century. This craftsman was named Nicholas Bataille. At one time he was valet to the Duke of Anjou, and in the cathedral of Angers there are specimens of the tapestry hangings produced under his supervision when he was in the service of the Duke of Anjou. The Register of the Treasury of the Duke of Anjou shows that in one case the Duke borrowed from his brother, Charles V. King of France, a MS. illuminated with scenes from the Apocalypse. An artist of repute, Hennequin or John of Bruges, was charged to make enlarged copies of these illuminations. These enlargements were then worked out by Nicholas Bataille and his staff. That the Duke of Anjou should have had the perception to cause an illumination to be thus enlarged, marks a taste no doubt inherited from his ancestor Charles of Anjou, who, on his journey in 1266 to assume the kingship of Naples, is said to have stopped at Florence, and visited Cimabue, then at work painting a Madonna for the Church of Santa Maria Novella.

The more notable tapestries of the 14th and 15th centuries appear to have been worked after designs from Flemish artists, who, as a group, were more able and distinguished at that time than their brethren in France. Gold and silver threads and silks were frequently and lavishly intermingled with wools for such hangings—with effects on a large scale similar to those of the small golden and glowing missal illuminations. We lose the effulgence and splendid colour of such works in photographs of them, which, however, give us the means of obtaining an impression of the careful study and drawing of the faces and draperies, as for instance in this diagram taken from a tapestry of the late 15th century. In this group we have a variety of faces displaying different expressions, depicted within the limits of this phase of art, as well almost as one could expect. Inequalities in scale and absence of perspective need not of course be particularised. Such features belong to the phase of work. They are often spoken of as elements giving the stamp of style; it should, however, be remembered that the designers did not work differently. They probably had no thought for "proprieties of style" such as we sometimes pretend to insist upon. Style, indeed, is a term which has grown into a respectful usage, through its repetition by persons belonging to a much later date. Good style or bad style serves as a general term to sum up excellencies and deficiences in groups of kindred works.

At the time that such a piece as this was made, the practice of tapestry-making had taken root in many parts of Europe—in France and Flanders especially, as well as, in a less degree, in England, Spain, and Italy. Flanders, however, seems to have been the district to which great patrons of art looked for the best work. A friend of mine has kindly referred me to Gaye's "Carteggio inedito artisti," &c. This contains reprints of interesting documents, amongst which is a letter written by Fruoxino, apparently a travelling agent of the Medici merchants. Dated from Bruges, 22nd June, 1448, it is addressed to Giovanni de Medici, a son of Lorenzo de Medici, who, with his brother Lorenzo, had, as leading members of the firm, carried on a very extensive trade. This letter relates to the efforts which the agent had made to buy some tapestries for his employer. The agent had been to Antwerp, but had met with little success there in getting what was wanted. He had seen a set of tapestries illustrating the story of Samson, but these, he says, would, from their size, be difficult to "hang in your chamber." The tapestry-makers worked, as a rule, to order, so Fruoxino advises Giovanni de Medici to send the exact size of the hanging he wants, and to name the subject which may be specially designed and worked for him.

It would not be possible for me to attempt giving you a brief account of all the known tapestry-making centres which flourished, with varying fortunes, during the 15th century. Sovereigns, pontiffs, and nobles did what they could to stimulate competition in the art. Paris and Arras had rivalled one another, and after the overthrow of Charles the Bold, Brussels came to the fore; Lille, Tournay, and Bruges, had also been and were to the fore. M. Muntz's excellent book on tapestry is replete with incidents of the rises, falls, and migrations of the art. From 1420 to 1500, swarms of tapestry workers, natives of Arras, Lille, Bruges, Tournay, and Brussels, swooped (as he says) down on the territories of the Marquis of Mantua, the Duke of Ferrara, the Duke of Urbino, on Venetia, Tuscany, and Umbria. The oldest Italian workshop hitherto known is that of Mantua. From 1419 a French tapestry worker remained in the service of the Gonzagas till about 1442. He was succeeded by other French and Italian workers. Thus, to a large extent, tapestry-making in Italy was indebted to an influx of Flemish and French workers.

On the other hand, an interchange of talent is indicated when cartoons by Cosimo Tura, Mantegna, and Leonardo da Vinci, were sent by the Medicis and others to be wrought in tapestry by the workers at Bruges. Vasari gives a minute description of a cartoon by Leonardo da Vinci for tapestry, which was to have been worked in Flanders, and presented to the King of Portugal. This intention was not fulfilled, and the cartoon alone was produced.

M. Muntz has closely tracked his subject. He gives much that is interesting about Italian tapestry works. He puts at rest a frequently accepted idea that Pope Leo X. caused Raphael's cartoons displaying the Acts of the Apostles to be worked at Arras; the fact being that the Arras works had collapsed some 36 years before the artist received his commission.

Before offering any remarks upon changes in design which developed soon after the commencement of the 16th century, I would show you a diagram of a closely filled design of the late 15th century, the tapestry worked from which is preserved at Rheims. We have here the coronation of Clovis, King of the Franks, in 481. The second incident represented is the siege of Soissons, five years later. This city was in the possession of the Roman King Syagrius. Further on is Clovis, with uplifted sword. He is no doubt engaged in combat with Syagrius, who was defeated and fled. The splendour of knightly panoplies, rich with resplendent armour, jewels, and sumptuous stuffs can almost be taken for granted even from this diagram. The composition with all its elaborated details reflects the later 15th century ideal of such feats of arms—performed by warriors led by Clovis; of whom, however, with a closer regard for truth than romance, it is written, that, "when he first took the field, he had neither gold and silver in his coffers, nor wine and corn in his granaries." Sets of great pieces like this of the Siege of Soissons, which is some 10 ft. or 11 ft. in height and 20 ft. in length, were taken about from place to place when their royal or noble owners changed residence. A waggon drawn by five horses carried the tapestries of Louis XI. on such occasions. The tents of Charles the Bold, Duke of Burgundy, were hung with great tapestries. Some of them are now preserved at Berne, having been captured in 1486 at the Battle of Gransons.

The quality of flatness, due to comparative absence of perspective, and the fullness of details so arranged as to produce a complex pattern, are features in finished designs wrought in tapestry during the later 15th and early 16th centuries. But these features rather quickly disappeared after the entry of Raphael and other Italian artists, upon the scene as designers for tapestry.

Henceforward, an impulse was given to the production of designs which the tapestry worker should render with as near an approach to realistic effects of light, shade, relief, and distance, as his fixed warps and bunches of coloured threads would allow him. This tendency to give tapestries a likeness to paintings has been, and is still developed, at the Gobelins factory. The steps leading to it from the simpler and flatter-looking designs of the 15th century are many, but not, I think, peculiarly interesting. Here, however, is a type of design which found much favour when produced in the 16th century. And here is another sort of type specimen of the 17th century. At the famous Mortlake tapestry factory, which was founded by James I. early in the 17th century, designs after Raphael, Rubens, and Vandyck, were worked, in which pictorial, as distinct from Gothic, effects predominate.

In conclusion, I return once more to the designs of the late 15th century, in order to place before you diagrams of a few remarkable specimens illustrative of the Triumphs of Petrarch. In connection with them I may refer to one or two specimens of other decorative work. These indicate the adoption by designers of allegories in illustration of which they made compositions of stately processions rich in ornamental detail. Mantegna's cartoons of the Triumph of Cæsar are preserved at Hampton Court, and are pre-eminently interesting in this respect. Here, taken from the Aldine print (of 1499) known as the dream of Poliphilo, are two cuts displaying the Triumph of Europa. From a decorated wedding robe chest or *cassone* (1480), I have taken the front panel, upon which, in the original, are painted the Triumphs of Love, Chastity, and Death.

As is well known, Petrarch wrote a series of allegorical triumphs, about the middle of the

14th century. The subjects of these are, the Triumphs of Love, Chastity, Death, Fame, Time, and Eternity. They are full of suggestions, but are much too long to quote on the present occasion. They, and the designs made a full hundred years later, are replete with detail; and the designs indicate that the poems were certainly known to the designers. Cupid is invariably represented as Petrarch describes, in a fiery chariot drawn by four snowy steeds. Chastity, in her white robe, bears "a fair pillar." Death is spoken of by the poet as a 'lady clothed in black," and designers select Atropos to represent her.

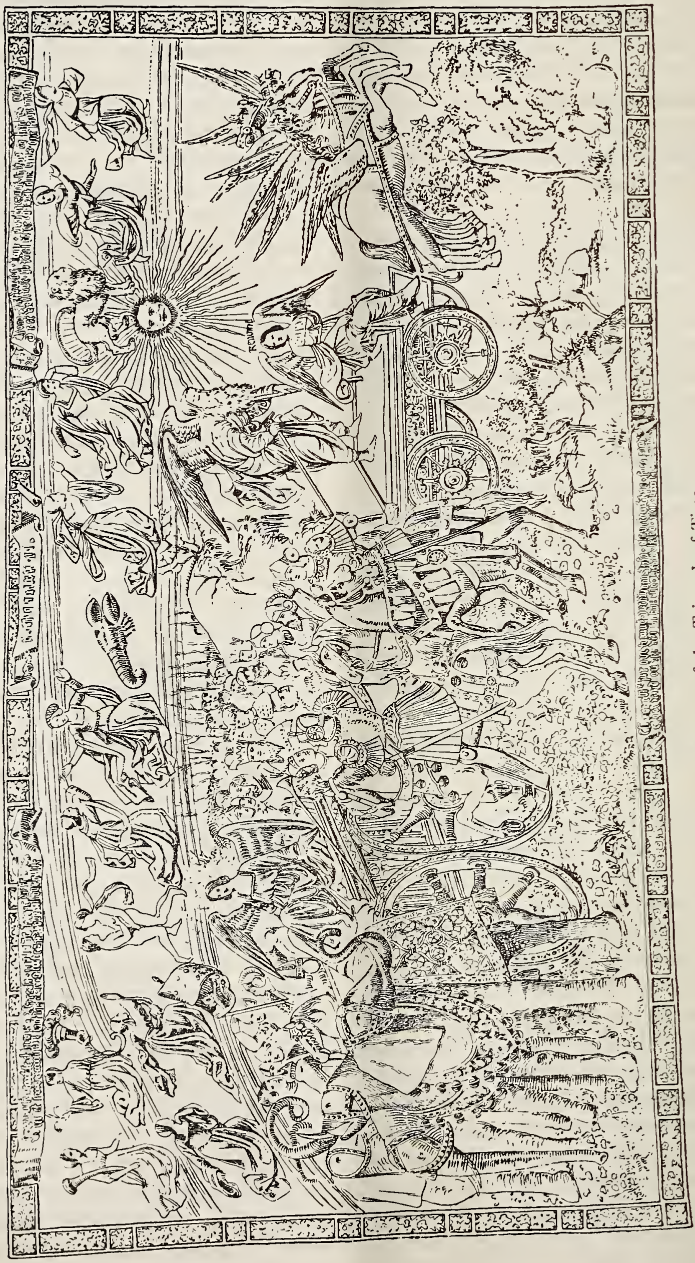
The scheme adopted by the designer of the tapestries of which I have two diagrams, gives two episodes to each tapestry. These episodes mark the triumph of the particular virtue or fatality which is preceded by the overthrow of the alien fate or antagonistic influence. These hangings measure 26 ft. in length and 14 ft. in height. In the case of the Triumph of Death, we have the overthrow of Chastity by Atropos. Then comes the actual Triumph of Death as typified by the "three fatal sisters of Destenye" seated in a car in which lies, dead, Chastity. Bullocks draw this car over a mass of dead and dying. A knight heralding the extinction of life and bearing two lances, one labelled Fortitudo and the other Malheur, cleaves a path through the crowd of illustrious defunct.

The second diagram is of the Triumph of Time (Fig. 4, p. 958). This is rather different in treatment from that of the previous tapestry. Massed in groups without much indication of feeling for perspective, the magnificence of terrestrial glories, historic facts, and ingenious materialisations have been pressed into the service for that; but now the designer, for his Triumph of Time, draws upon his imagination of ætherial entities, and as a salient feature of the upper part of his composition uses a semicircular arrangement of figures robed in white flowing folds typical of the hours, and floating before the zodiacal signs Gemini, Cancer, and Leo, into which the sun is entering. The first group on the left indicates Fame overthrown, whilst the second near the centre of the design is the triumph of advancing Time, an old winged cripple supporting himself with a crutch; the left crutch he carries in his hand, and he stands in a bent attitude over Fame vanquished. Both figures are on a car dragged by winged horses, into air over a wide-spreading landscape.

Late 15th century tapestries of the Triumph of Chastity, Death, and Fame, are in the South Kensington Museum. Corresponding tapestries of the Triumph of Death, Chastity, and Time, are at Hampton Court Palace, and have lately been admirably repaired. There are other very remarkable tapestries in the palace, but I cannot venture to speak of them now. Besides those at Rheims and Berne, to which I have referred, examples of these closely filled figure compositions are to be found at the Cluny Museum in Paris, and in great splendour at the Museum at Madrid. Some very remarkable specimens of the middle 15th century, which had belonged to the Chevalier Bayard, are in the collection of the late M. Achille Jubinal, whose writings on tapestries must always command respect. The tapestries in the Uffizi Palace at Florence, at the Vatican at Rome, and in the Garde Meuble in Paris, are extremely numerous, and generally of a later period. Scriptural, ecclesiastical, and natural history, classical mythology, middle age, and Provençal romance, poetry, and allegory, have influenced designers for tapestries from the 14th century onwards. Whilst pastoral, domestic, and sporting scenes have, in the 17th and 18th centuries, been reproduced in tapestries, sometimes even from the small cabinet paintings of artists, who probably had no idea that the perpetration of such doubtful compliments would be contemplated, much less carried out.

Now the points which I have endeavoured to establish are, briefly, that the term tapestry may be read in two senses; the one in which at all times it refers to hangings generally; the second in which it implies a special method of producing a textile fabric. The earlier hangings, although pains have been taken to prove that they were in a large degree made by this special process, appear, on the whole, to have been of lighter material than that of the special fabric; and the ornamentation on them was rendered by weaving, embroidery, or painting. Indications that the special process was known in early times have been given, but it was then applied to making small ornamental trimmings to costume. The application of the special process to the making of works on a much larger scale than that of such trimmings, seems to occur in the 12th or 13th centuries, although in old Asiatic civilisations it had probably been employed for carpets, the patterns of which were composed of formal, somewhat geometric devices, arranged symmetrically. The fame of tapestry hangings made by the special process rests upon the renderings of great figure subjects designed in the 15th century. The drawing, arrangement, and colouring of such, invest their application to textile hangings with an appropriateness of surface pattern. This cannot be conceded in respect of the later results of the special process when the rendering of subtle painting effects are attempted by the tapestry maker. In such phases of the art, regard to the peculiar use of the textile hanging, as well as to the limitations in employment of materials, is probably as unconsciously put aside as it was equally unconsciously displayed in the antecedent works of the 15th century.

Fig. 4.



Tapestry of the Triumph of Time.

It was out of my power to get my diagrams coloured; but to make up for this grave deficiency, the authorities of the South Kensington Museum have kindly lent the specimens exhibited in this room. Each is labelled, and

I hope that the sight of them, coupled with the information I have had the honour of laying before you, may lead you to recognise the high interest which attaches to a study of tapestry in respect of its use, its designs, and its method of production.

[This lecture was illustrated by a series of diagrams thrown upon the screen by means of the electric light.]

Miscellaneous.

◆

COLONIAL AND INDIAN EXHIBITION.

NATIVES.

It is thought that it may be of interest to preserve the names of the many subjects who have come from all quarters of the British Empire to be present at the Exhibition. The following list is classified according to the various colonies, and the trades and occupations of the natives are appended.

INDIA.

From Benares in the North-West Provinces.

	Name.	Description.
1.	Shàbàn	Gold brocade weaver (48).*
2.	Khàdim Hosen	Weaver (20).
3.	Amiralli	Kinkhab weaver (40).
4.	Emàmudin	Kinkhab weaver (45).
5.	Ismail	Kinkhab weaver (40).
6.	Asgar Hosen	Kinkhab weaver (14).

Delhi in the Punjab.

7.	Nazeer Hussan	Ivory miniature painter (36).
8.	Rahimbrux	Gold lace maker.
9.	Hajee Meahgan	Coppersmith (80).
10.	Nisar Ahmed	Seal engraver (24).
11.	Mogal Jàn	Silversmith (22).
12.	Mohamed Hosein	Coppersmith (23).

Agra in the North-West Provinces.

13.	Bilàyat Husen	Dyer (42).
14.	Mukunda	Calico printer (40).
15.	Karan Sing	Trinket maker (28).
16.	Hiralall	Sweetmeat maker (37)
17.	Tulsiràm	Sweetmeat maker (42)
18.	Bàke	Tapestry weaver (40).
19.	Khemchand	Goldsmith (42).

Mathura in North-West Provinces.

20.	Pitàràm	Carpet reader (22).
21.	Ràmphal	Carpet weaver (9).
22.	Bhupla	Tapestry weaver (18).
23.	Bipat	Carpet weaver (15).

Cawnpore in North-West Provinces.

24.	Ràmlall	Carpet weaver (9).
25.	Chuta	Carpet weaver (14).

Bhurtpur.

26.	Radha Ballabh	Architect (36).

Rajputana.

27.	Nathiràm	Architect (34).
28.	Ghasiràm	Stone-carver (20).
29.	Jogal	Stone-carver (50).

Bikanir.

30.	Kàdirbux	Stone-carver (42).

Lucknow.

31.	Munnàlàll	Clay figure maker (35).
32.	Jivanlall	Decorator (24).

Agra.

33.	Bakshiram	Potter (102).

Bijnor in North West Provinces.

34.	Kàdarbux	Wood-carver (30).
35.	Moulàbux	Wood-carver (20).

Bhavnagar.

36.	Harji	Bullock driver (35).
37.	Dosa	Bullock driver (25).

Bombay Servants.

38.	Van John Pillay	Madrassee butler (38).
39.	Maktan Ditha	Madrassee butler (21).
40.	A von Fernandez	Bombay butler (36).
41.	D. N. Fernandez	Bombay butler (32).
42.	Joseph Napoleon Pereira	Bombay butler (31).
43.	Ganu Bullah	Madrassee butler (24).

Burma.

44.	Hormusjee	Carpenter.

Nos. 1 to 35 work daily in the Indian Palace.

CEYLON.

1.	Don Juan Wimala Surendra	Muhandiram (or headsman) Goldsmith.
2.	W. E. Fernando	Carpenter.
3.	Chas. Hámi, a native of Galle	Goldsmith and cabinet maker.
4.	Chellappa	A Tamil native of Trincomalee. Butler.
5.	Don Brampi Pereira	A Peon (or messenger) in the Colombo Kachcheri. Arachchi by rank.
6.	H. Don Deonis	Attendants at the Ceylon Tea House.
7.	C. Don Williams	
8.	Allix Alexander	
9.	Martin Pereira	
10.	Paul Pereira	

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* The figures between parentheses denote the age.

All these men, with the exception of 2 and 3, can speak English, and can read and write fairly; all except 4, can speak, read, and write Sinhalese with facility. No. 4 knows his own language, Tamil, well.

The Muhandiram has a sound knowledge of Sanskrit and some acquaintance in the Páli (the language in which the Bhuddist scriptures are now preserved), he having read with the most learned Pundit in Ceylon; he has a good knowledge of English.

British Guiana.

Red Indians.

1.	Edward Seon	Interpreter and guide.
2.	William Austin	Arecuna, hunter (42).
3.	Christina Austin	Wife of the above, Acawoio, labourer (31).
4.	Catherine Austin	Child of the above, (5).
5.	Anthony Gordon	Macoosi, woodcutter; reads and writes English (24).
6.	Catherine Matthews	His aunt, Acawoio; labourer (32).
7.	Maria Matthews	Daughter of Catherine, Acawoio; reads and writes a little (8).
8.	Simeon Dance	Arecuna, labourer (26).
9.	Rebecca Dance	His wife, Arecuna, field labourer (24).
10.	John Dance	Child of above, Arecuna (2).

These people have all been baptised in the Church of England Mission. They cultivate land, fish and hunt, and are employed by wood cutters.

Cypriotes.

1.	Loucas Nicolaidis	Interpreter.
2.	Rodothea Petrou	Weaver.
3.	Catina Sophocli	Weaver, wife of Sophocles, and cousin of Rodothea
4.	Sophocles Haralambo	
5.	Marigo Constantinidi	Weaver.

Loucas comes from Varoshia, the rest from Nicosia.

Cape of Good Hope.

Malays.

1.	The Hadji Manan	House painter.
2.	Mrs. Elizabeth Manan	Wife of above, dress-maker.
3.	Georgina Manan	Daughter of above, dress-maker.
4.	Mahomet Assatz Manan	Baby.
5.	Jakoof Manan	Nephew to the Hadji, carpenter.

Natives.

6.	James Jeremiah	Tambookie Kafir, 22 years in police.
7.	Sarah Jeremiah	Wife of above.
8.	Lydia Jeremiah	Baby.
9.	John Kabua Selos	Gcaleka Kafir, ploughman.
10.	Andries Mafeana	Fingoe, ploughman.
11.	Klaas Jare	Bushman, shepherd.
12.	Martha Jare	Wife of above.
13.	Martha Jare	Baby.
14.	James Smart	Krooman, late Detective Department, Kimberley.

Nos. 6, 9, 10, and 11 are engaged daily in the diamond washing operations.

Straits Settlements.

Inchi Ibrahim	Carpenter,	from	Perak.
Inchi Orinar	,,	,,	,,
Wambon	,,	,,	,,
Awang	,,	,,	,,

These carpenters were sent over by the Government of Perak to erect the Malay-house; they went back soon after the completion of their labours.

Hong-Kong.

1.	Chun Quan Kee	Manager of Hongkong bazaar, Canton merchant.
2.	Quang Mang-chow	Sub-manager of Hongkong bazaar, Canton traveller.
3.	Chun Kin	Macao, head hotel boy.
4.	Quang che Sing	Canton traveller.
5.	Loo-ayow	Domestic servant, Hongkong.
6.	Li-Ping	Master blackwood carpenter, Canton.
7.	Ho-Hing	Coolies, Canton.
8.	Hi-Ti	

Nos. 1, 7 and 8, have returned home.

The number of visitors to the Exhibition for the week ending August 7th, was 259,528; making a total since the opening of 2,418,538.

TRADE OF GERMANY WITH HER COLONIAL POSSESSIONS.

The United States Consul at Frankfort-on-the-Main, in his report to the United States Government, on the extent to which Germany trades with her colonies through the ports of Hamburg and Bremen, says that, taking the trade of Hamburg with Africa, it appears that the imports from the West Coast, exclusive of the Cape and Morocco, but inlusive of the territories on the West Coast, which do not belong to Germany, amounted in 1884 to £665,000, an increase of £200,000, due chiefly to larger imports of palm oil and kernels, which amounted respectively to £187,500 and £387,500. Caoutchouc was imported to the amount of £45,000, coffee £20,000, elephants' teeth £10,000, and other articles to £5,000. The imports from the East Coast amounted to £55,000 last year, or £20,000 less than during the preceding year. They consisted chiefly of hides, orchilla, sesame seed, and copra. The port of Bremen has no imports of any consequence from the East of Africa, but its imports from the West Coast, not including the Cape, amounted last year to £15,000. As regards the exports, Hamburg consigned to Western Africa last year merchandise to the amount of 53,150 tons, against 44,000 in 1883, and 41,000 in 1882. Spirits formed a very considerable part of the exports to West Africa, namely, 35,089 tons, and of gunpowder 1,618 tons were exported. Hamburg's exports to the Eastern portion of the Continent amounted to 2,368 tons, against 2,830 tons in 1883, and 1,104 tons in 1882. In these exports, spirits only look a very small part, as the Mohammedanism of Zanzibar is hostile to spirits. Bremen's exports to the West Coast amounted, in 1884, to £22,100 against £12,900 in 1883, and £31,300 in 1882. The exports of Bremen to the East of Africa were £3,250, in 1883, and £286 only in the year 1884. Of less extent is the trade with the Polynesian possessions, and in this Hamburg only comes under consideration, as the trade of Bremen is restricted to the Australian mainland, New Zealand, Hawaii, &c. The imports of Hamburg, in 1884, from the Caroline Islands amounted to £7,000; from New Britain to £6,000; Society Islands, £13,000; Marshall Islands £10,000; and Navigator's Island to £4,000, making a total of £40,000. To these amounts may be added £22,000 for the English Fiji Islands, against £63,000 in 1881. The value of the exports from Hamburg to Polynesia cannot be stated, but the amounts were as follows, in 1884:—to New Britain, 92 tons, against 537 in 1882; Society Islands 374 tons, as compared with 561 in 1883. Marshall Islands 128 tons, against 1,148 tons in 1880; and to Navigators Islands 1081 tons. The merchandise exported to the Fiji Islands, in 1884, amounted to 59 tons, compared with 199 tons in 1883. In conclusion, Consul General Mueller says that, comparing the imports and exports of the East and West Coasts of Africa with the total German imports and exports, it appears that the imports do not amount to more than ·5 per cent. of the total imports, and the exports to ·4 per cent. of the total exports.

The Director of the New York Mint reports that the production of gold in the United States during 1885 is estimated at $31,800,000, showing an increase of $1,000,000 over the estimated production for 1884.

Obituary.

ANDREW CASSELS.—Mr. Cassels, who for many years was a prominent member of the Society of Arts, died on the 2nd inst., aged seventy-four. As a young man, in the course of his mercantile education, he spent several years on the Continent, where he had good opportunities, of which he thoroughly availed himself, of becoming an accomplished French and Italian linguist; and he acquired a good critical knowledge of music and painting. He went out to Bombay as a partner in the great Manchester firm of Peel and Co., and was a well known member of society there for many years. After his return from India to England, and retirement from business in Manchester, he settled in London, and soon took an active part in many important undertakings. He was one of the directors of the Metropolitan Railway, and until he was appointed to the India-office held the responsible post of Chairman of the Board of Directors of the Bank of Australia, India, and China. He accepted from Lord Salisbury the appointment of member of the Council of India, and his services in that capacity were so highly appreciated, that his numerous friends made strenuous efforts for a prolongation of his tenure of office on the expiration of the statutory term; this, however, it being the first case of the kind, was refused by the Government as inadmissible. Mr. Cassels was one of the committee of the Society of Arts to whom Prince Albert personally presented medals he had struck for the occasion in recognition of their aid in the organisation for the Great Exhibition of 1851. He was an auditor of the Society's accounts in 1870, and elected on to the Council in 1872. He was vice-president in 1875, and from that time until the present year he was almost continuously an active member of the Council. He read, in December, 1869, a paper on the question of "A Gold Currency for India;" and took a constant part and interest in the work and meetings of the Society, particularly in the Indian Section, until two years ago, when he experienced a stroke which left him deprived of the power of speech. He was buried in Brompton cemetery, on Saturday last.

ROBERT JAMES MANN, M.D., F.R.C.S.—The news of the sudden death, on the 4th inst., of Dr. Mann, Member of the Council of the Society of Arts, and for many years Secretary of the Foreign and Colonial Section, will have been received with feelings of great regret by a large number of members of the Society. Dr. Mann was born at Norwich in January, 1817, and was educated for the medical profession at University College, London, and acted as dresser to the celebrated Liston when at the hospital connected with the college. He took his degree of M.D. at St. Andrew's, and was in practice for some years in Norfolk. In 1853, the state of his health caused him to partially abandon the practice of his profession, and he devoted himself more exclusively to literary pursuits. In 1857, on the invitation of Bishop Colenso, he left England for Natal, where he resided for nine years. During seven of these, he was Superintendent of Education for that colony, an office established by the then Governor, Mr. (now Sir John) Scott, and to which he received the first appointment. From his first reaching Natal, he daily made and recorded meteorological observations, the tabular results of which are deposited at the Meteorological-office. In 1862, he was the chief organiser and despatcher of the exhibits of the colony in the Great Exhibition of that year in London, and he arranged and carried on a preliminary exhibition at Durban. He returned from Natal in 1866 with a special appointment from the Legislative Council to promote emigration, which he held for five years. In 1874, Dr. Mann was appointed Secretary to the African Section of the Society of Arts, the name of which was subsequently changed to that of Colonial and Foreign Section. He resigned this appointment at the completion of the last session in consequence of the state of his health, and at the last annual meeting he was elected a member of the Council. He was one of the Board of Visitors of the Royal Institution, and was for three years President of the Meteorological Society. He was also a member of the Astronomical, Geographical, Photographic, and other societies. His earliest paper was on a botanical subject in the "Magazine of Natural History," 1840. His contributions to scientific periodicals, enumerated in the supplement to the Royal Society Catalogue of Scientific papers, number 23. He was for many years on the staff of the *Edinburgh Review*, and one of his latest pieces of work was an article on the recent progress of astronomy, which appeared in that review for April of the present year. He also wrote several popular scientific treatises, amongst which were some on domestic economy and household management. The protection of buildings from lightning was a subject on which he wrote much, and for which he did valuable work. His attention was more particularly drawn to this subject by the prevalence of thunderstorms in Natal. There was no Exhibition in which Natal made any appearance to which his helping hand was not given, and the last work he was to do before his death was to compile the catalogue for the Natal Court in the Colonial and Indian Exhibition. He had carried the catalogue into a second edition when death overtook him. He was struck down by an attack of paralysis, which, followed by bronchitis, proved fatal within 48 hours. He was buried at Kensal-green Cemetery on Monday, 9th inst.

General Notes.

PUBLIC SCHOOLS AT ROME.—The number of schools at Rome during the scholastic year 1884-85 was 141, or nine more than in the preceding year. The teachers numbered 571, or 60 more than in 1883-84. The number of pupils was 23,259, an increase of 1,158 on that of the preceding year, which was 22,101; the number of pupils examined was 16,030,, of whom 13,030, or 81 per cent., were promoted to a higher class; last year the proportion was 79 per cent. The prizes awarded were 1,325 first class, 1,060 second, and 6,378 honourable mentions; in all, 1,230 more than the previous year.

THE AUSTRIAN JUTE INDUSTRY.—The *Deutsche Leinen Industrielle* quotes details of the imports of jute into Austria during the three quinquennial periods 1871-1875, 1876-1880, 1881-1885, which show (notwithstanding extensive annual fluctuations) a yearly average for the three periods of 932, 1,993, and 4,823 tons. The imports of the jute yarns were, in 1885, about 248 tons as against 139 in 1884. This latter figure, however, displayed a marked reduction as compared with 1882. The increased activity of jute weaving in Austria is thus illustrated, and though the industry necessarily fluctuates to a certain extent with the demand for grain sacks, the trade is considered to display features of general stability.

THE ST. GOTHARD RAILWAY.—The influence of the St. Gothard Railway in reducing the traffic on the French lines is shown by the falling off of the receipts on the section of railway between Culoz and the Italian frontier (90 miles), which were during the last five years as follows:—

1881	7,216,690 francs.
1882	7,096,636 ,,
1883	6,658,870 ,,
1884	6,008,711 ,,
1885	5,268,521 ,,

The exports from France in 1883 showed a falling off to the value of seventy-two million of francs, as compared with those of 1881, whilst the exports from Germany showed an increase of forty-seven millions of francs during the same period.

MANUFACTURE OF OIL FROM WOOD IN SWEDEN.—A new industry has lately sprung up in Sweden, and promises shortly to become a most important one. Oil for illuminating purposes is now manufactured in that country from the stumps and roots that remain in the forests after the timber has been cut. These are subjected to a process of dry distillation, and besides wood oil, many other products are obtained, amongst which turpentine, creosote, acetic acid, wood charcoal, tar oils, &c. This oil cannot be used in ordinary lamps, as containing a large proportion of carbon it gives off a great deal of smoke during combustion. When mixed with benzine, however, it may be used in ordinary benzine lamps; but when burnt alone, a special lamp must be adopted. The trees that furnish the greatest amount of oil are the pine and fir. There are now about forty establishments engaged in this manufacture in Sweden.

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FRIDAY, AUGUST 20, 1886.

All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

NOTICES.

PRINCE OF WALES'S TESTIMONIAL FUND.

Members of the Society desiring to take part in the subscription to the above fund can obtain collection forms from the Secretary, who will also be happy to receive, for transmission to the Hon. Secretaries of the Fund, any subscriptions from members or their friends. No subscription is to exceed two guineas. Contributions may also be sent direct to the Hon. Secretaries to the "Prince of Wales's Testimonial Fund," Bank of England, Burlington-gardens, London, W.

It is the desire of the Testimonial Committee to preserve the names of all subscribers. Names and addresses should, therefore, be carefully given.

H. Trueman Wood, *Secretary.*

Proceedings of the Society.

CANTOR LECTURES.

THE ARTS OF TAPESTRY-MAKING AND EMBROIDERY.

By Alan S. Cole.

Lecture III.—Delivered April 19th, 1886.

[The right of reproducing these lectures is reserved.]

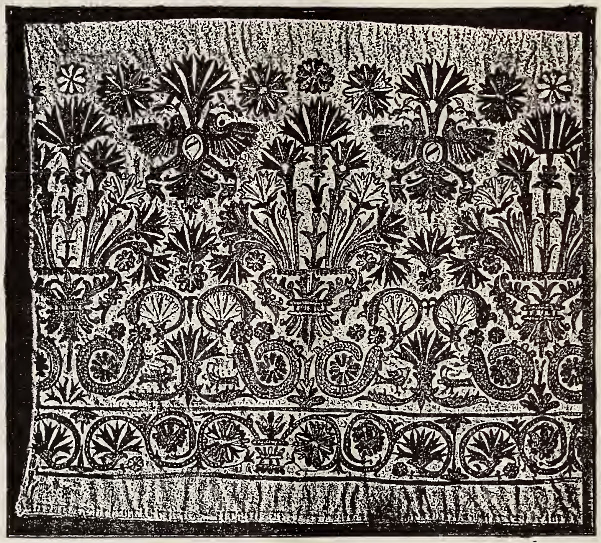
It will, I think, be convenient for me to commence my lecture this evening by shortly stating what I understand by the term "embroidery." In the first place, it applies to the ornamental enrichment, by needlework, of a material. Such enrichment may be produced with various materials, similar to or quite different from that into which it may be worked. In many instances, the enriching material is more costly than that to which it is applied; though works beautiful in effect have been made in which the embroidery is of the same material as its ground or foundation. We may notice instances of these as we proceed. Under the definition just given, embroidery may be classed into two broad divisions; the one of embroidery done on one side only of a material; the other of embroidery done with equal finish and effect on both sides.

Ever since man has been known to exist, needlework of some sort has been done. The needle, as successively made of bone, wood, and metal, is many thousands of years old. When, therefore, we begin to investigate the embroidery of the first historic nation, it is not surprising to find it well established as an art, more or less, of common practice. As we proceed, we find that almost the same character of conditions which have favoured the practice of embroidery has repeated itself throughout the world.

Some notion of this repetition may, perhaps, be gleaned by comparing the work done by the civilised child with the work of an adult belonging to a race or nation in comparative primitiveness. The likeness which may often be traced between such work marks an approximate equality in ability. And, as we go through history, we seem to find that the habits and practices of the earliest historic nations more or less correspond with those of people at the present day who are regarded by us as being in a primitive stage of civilisation. But the small indications which I have hastily perceived, and inadequately followed up, in regard to this matter, convince me that it is far too large to be fitly discussed now. In illustration of the relationship which establishes itself between, say, the work of a school child under discipline and that of a peasant who has little or no instigation to rise above a certain standard of performance, I would suggest your looking at samples worked by 17th century school children of twelve and fourteen years of age, and 19th century peasant embroideries, say, from remote villages in Norway. The designs represented differ but slightly, whilst the quality of performance is fairly level. Again, we may examine specimens made by other people quite remote from one another, but apparently subject to one and the same sort of influence. And as exemplifying similar character of design, all of them suggestive in composition, stitchery and colour, actual specimens of Spanish, Persian, and Cretan embroideries are exhibited. In patterns on specimens from Crete we find signs of the influence of a mixture of ideas. Here (Fig. 1) for instance is a border for a petticoat, of canvas embroidered, in the 17th century, with many coloured silks in various stitches—chief amongst which is a sort of long, cross, twisted-thread stitch. This stitch is much affected by the mixed races of the Grecian Archipelago.

The pattern of this border consists of a band with floriated scrolls springing from each side of a central device, above which is a series of vase or basket motives. Out of these come bunches of carnations; between these appear double eagles and symmetrical arrangements of variegated carnations. In the lower portion of the pattern are S shapes, terminating in carnation blossoms. Birds of an archaic type are also introduced. Incidentally, I may say that the double-headed eagle occurs as a device upon Karamanian coins of the 10th century, and upon pre-Mohammedan coins. Mr. Purdon Clarke tells me that the bird with two heads is as often introduced into ornament in the south of India as it is in ornament from Tibet and in cloths from Yarkund. He believes its use to date from classic periods. The double-headed eagle of Charles V.'s time is thus comparatively quite modern. The same sort of motive of course appears in embroideries from Persia—of which there are designs wrought in a way similar to those of the specimens shown, wherein the carnation blossom is a prominent feature. Again, in Spanish embroidery of the 17th century, the double-headed eagle is naturally a usual device. In this specimen of Spanish work one may trace a kinship, its crowded and orderly arranged ornament, and its somewhat startling colours claim with those of patterns to be seen in work from Crete. The class of flowers, chiefly tulips, in the Spanish specimen, the real forms of which are somewhat obscured by ornamental treatment, is, however, quite different from that of the Cretan patterns. Still, carnation forms are abundant for patterns, not only Spanish, but also Italian and German of the

FIG. 1.



Silk Embroidery on Linen of Cretan workmanship. Probably 17th century.

17th century, and the ornaments made with them recalls that to be noticed in Cretan, Syrian, and Persian specimens.

For the most part, the embroideries to which I have been alluding might be grouped as peasant work; and the facts I have suggested go towards confirming the likeness which exists between the works of similarly circumstanced people, who have produced works of similar ornamental character and needlework quality.

On the occasion of my first lecture, I attempted to bring forward some rather well-known points in connection with the development of designs and patterns. The specimens we have before us, and those I propose to show, will suggest a multiplicity of considerations concerning motives and their treatment in making patterns. Time will not permit me to do more than glance at such considerations, however, and I propose to devote the greater part of this lecture to an examination of the stitches.

Broadly speaking, the more complete and finished embroideries are such as have been made by workers who have given themselves up to the craft as to a life-long profession; at the same time, specimens of needlework of great excellence often issue from the hands of those who possess a dexterity which they exercise for occasional enjoyment rather than from regular necessity. Groups of embroiderers, pursuing their art with regularity and under conditions of organisation—a natural necessity of thriving crafts—are to be met with in many countries and at various periods. With Eastern people like the Chinese, Japanese, and Mohammedan races, embroidery rises to a degree of perfected practice bespeaking a sort of second nature centuries old. In Western and Central Europe there seems to have been no such pronounced settlement of practice. Certain phases occur, as when a domination of ecclesiastical authority is apparent, and, later on, when a fashion was maintained in making imitations of the imported Oriental work, and again when embroidered costumes were in vogue. In Polynesia, Africa, and the New World, embroidery has been an art with tribes slow in changing their customs, or, so to speak, in passing up the ladder of civilisation. In this regard, they resemble the peasant peoples in other more civilised parts of the world. As a domestic or home industry, embroidery is frequently distinguished by admirable [skill, although the patterns depicted may not indicate any corresponding quality of trained perception in drawing, selection of colours, and arrangement. The constant regular employment which is possible in workrooms specially devoted to the purpose, in religious houses, or in Eastern harems, has naturally left its mark upon the work produced within them. So, too, has that conservative quality of keeping things in families, as with a tribe or village of peasants, who adhere to a particular sort of stitch or style of design, and acquire great skill in doing it.

But the modern system of human industry aided by machinery inevitably affects the recurrence or prolonged existence of such circumstances as those glanced at. As the modern system gradually extends its scope, people adopt new processes and new habits for the old, and, except under special provisions, embroidery by hand is not likely to be exempted from its effect. Such as perceive the charms of embroidery, and are willing to pay the rate of wages which shall induce workers to keep to the handicraft, may contribute to the maintenance of this art; but unless a revolution in the influence and spread of machine-aided industry takes place, it is hardly likely that embroidery will take such a position in the future as it has held in the past.

One usually associates women with the art, but it must not be forgotten that men have been, and still are, amongst its foremost adepts. In India, China, and Japan, the art owes its best expressions to men. In Europe, it probably owes more to women, though members of religious communities, like Benedictine monks in past times, have excelled in the use of the needle. Abbot Wygmore, of the 14th century, was a proficient embroiderer, and the brethren at Woolsthorpe, in the 16th century, wrought much excellent needlework. Similar instances could no doubt be quoted of other countries.

In dealing with tapestry-making last Monday, I adopted the method of chronologically showing a rise and development of that art. I might, perhaps, discuss embroidery somewhat differently, dealing with it as it appears in various countries. To do so, however, would, I find, involve duplication of remarks. I, therefore, propose to avoid this as far as possible, by grouping together similar features as we find them, and speaking of them without much digression as to country and period of production.

In the first place, stitches, I think, should claim attention, although designs and patterns are equally important; but the time at our disposal makes it impossible for me to fairly deal, even briefly, with both of them. Designs and patterns frequently conjure up a variety of interesting topics, apart from their demonstrating suitable selection of subjects, composition, drawing of forms, and mingling of colours. The subjects pourtrayed often incline one to enter into considerations of history; the probable date of production is usually a fertile source of discussion; whilst ethnography, in its attempts to determine national characteristics, perplexing and attractive as are its ramifications, not infrequently throws a cloak of excuse over absence of skill in craft and design, and a work of doubtful art becomes elevated to an importance the significance of which is not always intelligible.

The late Canon Rock, who has written with enthusiasm upon textile fabrics and embroidery, made out a classification of sketches by means of certain titles which he found in Dugdale's "History of St. Paul's." There, as well as in old records, inventories, and such like, he found mention of classes of work, such as *opus anglicum*, *opus plumarium*, *opus pulvinarium*, *opus pectineum*, and *opus consutum*. Following his suggestions, I adopted these classifications for a catalogue of a large and unique collection of decorative needleworks which was exhibited in 1873 at South Kensington Museum. Since then, however, closer scrutiny of the precise meaning of these Latin titles seems to me to have demonstrated their comparative uselessness in conveying definite technical information. No authorities clearly show what the *opus anglicum*, for instance, really was, whether it was a chain or a split-thread stitch, or, as Dr. Bock, of Aix-la-Chapelle, suggests, bead work; and I say this with some deference in view of opinions given in a large book upon needlework recently written by Lady Marian Alford, who has done so much to further practice of the art. The term seems to imply that at a certain time—about the 13th and 14th centuries—English embroidery, especially on ecclesiastical vestments, was in high repute. But a number of specimens of the same character as that attributed to the *opus anglicum* were made abroad, and hence a doubt is thrown upon the peculiarly English nature or style of this embroidery. The temptation to closely investigate the special and technical distinction of *opus anglicum* is strong; but it would obviously take one far away from examining embroidery, and from arriving at a knowledge of stitches generally.

Earlier in my lecture I said that we might divide embroidery into two classes—the one in which the work is made for display on one side of the material; the other in which it is equally finished on both sides.

In respect of the first of these classes, I have diagrams of seven stitches (Fig. 2, p. 967) which are made for display on one side of a material. They are worked by drawing the needle with its thread in one sweep through two or more places along the surface of the material. The simpler of such stitches are—long and short stitch—as here. Then there is a stem stitch. This, as shown here, merely implies an oblique arrangement of short stitches. Feather stitch, or *opus plumarium*, is another term used in embroidery, but here again we find that it means an arrangement of long and short stitches, so taken as to completely cover a portion of the surface being worked upon. In plain needlework, however, as distinct from embroidery, there is another arrangement of long and short stitches for seams, to which the name of "feather" stitching has been also applied.

Running and darning (closely similar in effect on both sides of the material) may involve the use of long and short stitches, but instead of the needle passing at one sweep through two places only, it has to be stealthily worked through half a dozen or more. Chain stitching involves the looping of the needle's thread in the progress of the stitch. Sometimes, instead of making a loop, the point of the needle is made to split the thread, thus giving a looped character to the stitch. Knotting stitch is another development of the looped stitch. In this case the needle makes a passage down through the material, and not along it, and a knot is so formed on its surface. Tent, cross, and cushion stitches are often worked upon an open reticulated ground, such as canvas. They are supposed to constitute the group of *opus pulvinarium*. But we find tent and cross stitch are the principal stitches used, with marvellous patience, by Mohammedan embroiderers in the intricate and richly-coloured ornamentation of leggings for ladies, the material of which is of closely-woven linen or canvas. Here, for instance, is an employment of red silk worked in cross-stitches to cover the ground about a pattern, the leading forms of which are of the linen fabric which the embroidery ornaments. This is sometimes called Italian work of the 16th and 17th centuries, sometimes Spanish. Specimens have also come from Albania, and from one or other of the Cyclades.

FIG. 2.

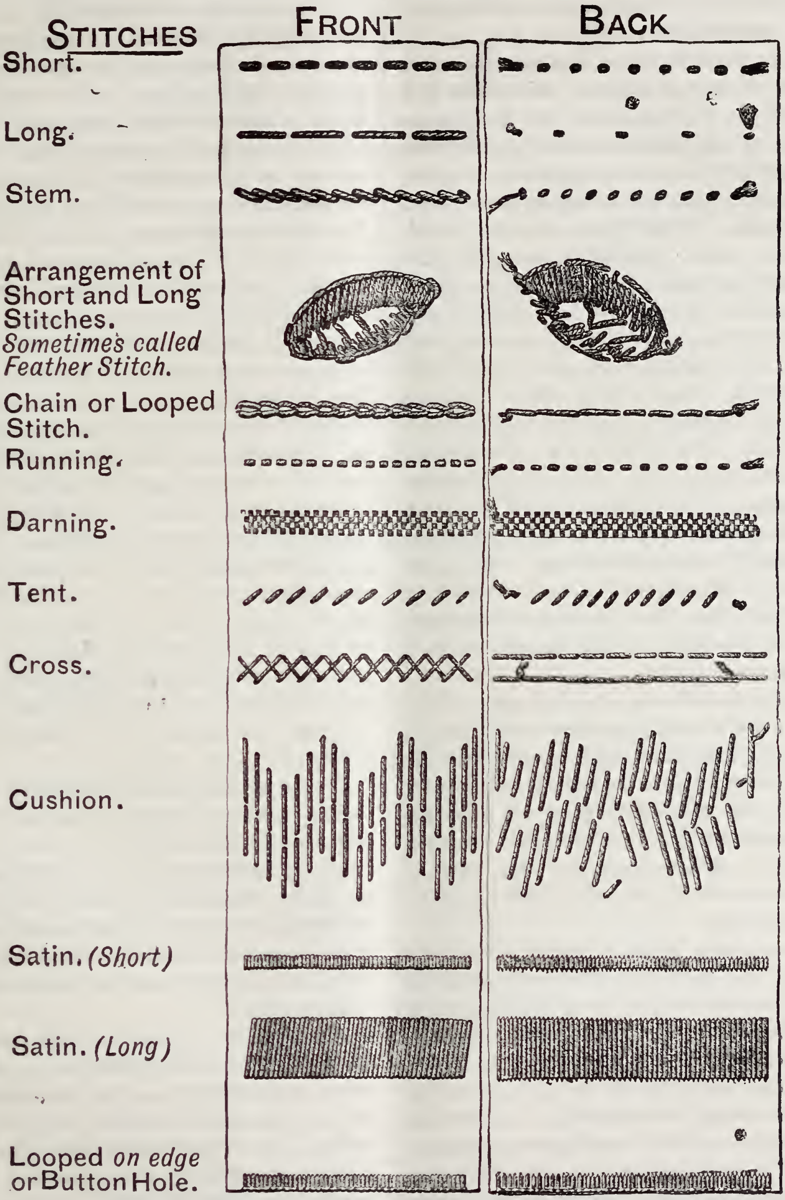


Diagram of Stitches: showing their effect upon the front and back of the material into which they are worked.

The making of tent, cross, and cushion stitches differs from that of the long, short, and looped stitches. The needle is passed up through the material, and then down again through its face. In cushion stitch the Germans have much delighted. Berlin wool work is often done with cushion stitch. The Swedish have distinguished themselves for some centuries in such work, the patterns or which are primitive in form and garish in colour. Such works are not, however, of such pretentiousness as the *tapisserie au petit point* of the French. Here is a specimen of such tent and cross-stitch work of the 16th century. The fashion for it found followers in Italy and England. The stitches we have so far considered are chiefly for decorating one side of a material only.

Now, the second class for obtaining equal effects on both sides, includes satin stitch and tapestry stitch, which latter is not to be confounded with the *tapisserie au petit point* previously named. As shown in the diagram (Fig. 2, p. 967), satin stitch may be of long and short stitches. From Italy and the Greek Archipelago come specimens wrought with much finish in this stitch. This specimen is simple in its pattern of leaves and branches with horizontal, perpendicular, and oblique satin stitches worked across the various forms. The colours, which I regret cannot be displayed, are of light blue, salmon, and golden-hued tones. The French speak of this satin stitch as *au passé*, and as *sans envers*. The owner of this specimen considered that it was of Venetian workmanship, dating from the 16th century. But other authorities declared that it was Turkish of the 19th century. The controversy does not diminish the virtue of the specimen as a finished piece of work.

Returning once more to the diagram of stitches, I wish to direct your notice to the form of looped stitching which has been done upon the edge. This is called button-hole stitch. It may also be done upon a thread. Here is a diagram of it made upon a couple of threads. When used in this way to render a pattern, the result of the work is needlepoint lace.

We have thus briefly glanced at some thirteen or fourteen stitches, five of which classify themselves into a single group, as long or short stitches; four as looped stitches; whilst the three stitches known as tent, cross, and cushion are virtually the same, and so may come under one heading; satin stitch differs from all of them, and therefore takes a place by itself. Thus we have not more than four distinctive groups of stitches. And now, turning to the tapestry stitch, it is, I find, supposed to be a peculiarity of the *opus pectineum*, or work done in a loom or frame, and in the process a comb is used. This implement, as we noticed last Monday, is one of importance to the tapestry maker. Tapestry stitch, however, as wrought with a needle, does not require the employment of a comb to compress the intertwisted threads together. Here is a specimen of work from Skäne in Sweden. The original specimen, to be seen below, is square. Only half of it is shown. The specimen is made up of bands of needlework and lace called "Klutaband." These are first used by peasants for the broad ends of cap-lappets, subsequently they are joined together into squares. The bands of geometrical pattern—flanking the lace insertion—are those worked in tapestry stitch; the threads, corresponding to the warp of regular tapestry, are such as have been left of a strip of linen from which a number of warp and weft-threads have been withdrawn in a certain space. The tapestry stitching has then been worked in and out and between these threads, and is so managed that both sides are alike. In regular tapestry-making only one side of the production is presentable. From Persia come squares dating from the 17th century, very often of extraordinary minute needlework, done on loosely woven linen or cotton, in which a tapestry stitch identical with the Swedish is done. Work for the decoration of robes by Egyptian Coptics was not needlework. It was done with a small "slay," such as the tapestry maker uses. And this work is the same in process as that of tapestry-making. Here is a specimen of Egyptian Coptic work, probably of the 4th century of the Christian era. This, however, like tapestry, is presentable on one side only.

In connection with the Swedish and Persian needle version of tapestry making, I spoke of withdrawing threads from the material. There is a considerable group of embroidery known as drawn work, the essential feature of which is the withdrawing of threads in order to obtain open devices in patterns. Here is a specimen of such work taken from an Italian shirt of the 16th century.

A reversed counterpart of such drawn thread work is embroidery done with a darning or running stitch upon an open reticulated ground or net—as in this example, which is probably either French or Italian of the late 16th or early 17th century. A phase of this work survives in the embroidery on net of many countries; in Ireland, amongst others, where it is called Limerick lace or run-work.

Running, done in close material, results of course in quite a different effect from that of running on an open ground. Here is a specimen of worsteds run into a linen. It is an

Icelandic work of the 16th or 17th century. Here is a fragment of similar work, very simple in pattern, which came from a tomb at Sak-karah, in Lower Egypt, and may be of the 4th century.

Thus from *opus pectineum* we have been led to note certain ways of dealing with materials of close and open fabric into which embroidery is worked. We have not, however, increased the number of distinctive groups of stitchery, although their application has been varied. With some fancy, a Latin name has been assigned to the drawn threadwork, and it has been called the *opus araneum* or *filatorium*. But both denominations are valueless from a technical point of view.

The *opus consutum* has now to be referred to. The term applies to the cutting of materials into ornamental shapes, which are afterwards worked with stitchery of some sort. Here, for instance, is another part of the Italian shirt already referred to, in which simple details in a pattern are produced by cutting out bits of the ground.

Another sort of cut work consists of cutting away the ground about a pattern, first outlined with a cord or thread, and, where necessary, inserting little bars or tyes between the portions of the pattern. This work has been done hundreds of years ago in Italy, and is done in Ireland at the present time, at Carrickmacross. Here is a specimen of the cut work from Carrickmacross. With your permission, I should like to digress here to allude to a movement which has been made towards the improvement of patterns used by the Irish workers. In a sense, this movement owes something, I think, to this Society, for having given me the opportunity, in 1881, of delivering some lectures on lace-making and lace patterns. In the following year I was called upon to give similar lectures elsewhere, and, amongst other places, I lectured at Limerick, Cork, Dublin, and Belfast. The outcome of these lectures in Ireland has been the movement I referred to. A competition amongst pattern designers was held last year. Prizes were awarded to the value of £74 for some forty designs. Of these, a dozen or more are now being worked at some six or eight lace-making centres, schools and convents in Ireland. One has been finished for her Majesty the Queen, who was graciously pleased to give a commission for it and other prize patterns. Here is a specimen of the new piece of Carrickmacross cut work made for her Majesty. In the course of a few months, I hope that a sufficient number of needlepoint laces, embroideries upon net, and cut works will have been produced by the Irish workers to form a collection for public exhibition, and, at least, to demonstrate that the sale of Irish lace need not be entirely dependent, as it too often has been, upon a sort of philanthropic patronage.

Returning now to our review of cut works, we may note a variety kindred to the last sort of work. Here, again, the ground has been cut away, and the pattern left. But the pattern is so planned that the details composing it touch one another in places, thus getting rid of any necessity for inserting bars or tyes. The edge in the original of this border is enriched with gold thread. The pattern itself appears in one of the numerous Italian pattern books of the 16th century, without a full reference to which no history of embroidery is complete. They are often held to be lace pattern books. This is a mistake; a great number of the patterns are for many classes of decorative work besides lace.

Two more groups of cut work have to be noticed. The oldest of these appears to be patchwork. This is often associated in one's mind's eye with quilts made of hexagons in pink, and white, and lilac, such as one occasionally sees in peasants' cottages, or floating upon clothes lines in back gardens. From these, however, I have now to take a great step. In 1881, excavations at Deir-el-Bahari, in Egypt, brought to light a canopy, of which Mr. Villiers Stuart, in his book entitled "The Funeral Tent of an Egyptian Queen," has given a highly interesting and large coloured plate. He speaks of this canopy as a perfectly unique example of Egyptian tapestry, using the term as implying a hanging or covering of some sort, and not as involving any technical process. For, of the actual technical character of this canopy, Mr. Villiers Stuart tells us it may be described as a mosaic of leather work, consisting of thousands of pieces of gazelle hide stitched together with coloured threads to match. It is, in fact, a patchwork. The colours of the pieces of leather thus stitched and patched together, consist of bright pink, deep golden yellow, pale primrose, bluish green, and pale blue. Vultures, hieroglyphics, with diaperings of daisy blossoms, and borders containing goats, scarabs, and repeated fringe device, are the principal details to which the bits of gazelle hide have been shaped. Arranged in formal order, they make the pattern of this canopy. Mr. Stuart was able, from various data, to fix the period when this patchwork was made at 980 B.C. It was wrought for a queen who was mother-in-law to the Shishak who besieged and took Jerusalem three or four years after the death of Solomon.

Made in a very similar way to the Egyptian queen's canopy, but of different materials, is a French hanging of the 13th or 14th century. Here is a photograph of it. The design represents various incidents in a knight's encounter with a dragon. The details are cut out of different coloured cloths. These have then been sewn or patched together, and then applied to the ground; the seams between the patches being overlaid with narrow strips of leather. These latter were whipped round with fine golden strips suggestive, as Canon Rock says, of the lead lines in stained glass. In stained glass, the leading is necessary to hold the bits of glass together, whilst in this patchwork the corresponding lines are used for decorative effect, and are not constructive necessities.

From Persia at the present time (doubtless an inheritance of old practice) come gaudy patchworks (of Resht) done with much elaboration in pattern. Here is part of a large cover wrought in this way. The enrichments to the simple patchwork are worked in chain stitch with silks.

Amongst the specimens exhibited you will find examples of Italian patchwork in velvets and silks, so used as to produce alternations in colour of the same pattern. A similar effect of alternation is to be seen in the cut brass and tortoiseshell work associated with the name of André Boule.

Another section in the class of cut work is to be seen in what is known as applied or *appliqué* work. In illustration of this, I have a diagram taken from part of an altar hanging belonging to Sir William Drake. It is of Italian origin, and dates from the 16th century, somewhat later than the period which Vasari assigns to the production by Sandro Botticelli of designs for cut work. Vasari speaks of the work as *di commesso*. It is not clear, however, that this expression should specially indicate either patch or *appliqué* work. It may apply to both. In any case an interest is aroused by the association of Botticelli with decorative needlework. *Appliqué* work differs from patchwork, since the details of the pattern to be worked by the *appliqué* method are cut out of a stuff and then stitched down to a ground of material, which latter plays a visible part on the ornamental effect of the finished work. As a rule, the cut pieces thus applied are edged all round with stitches or with a cord or thread, also applied and stitched down. Finished and clear definition is thus given to the different shapes. This stitching down is virtually identical with tent stitching. It is the principal stitch used in other variations of applied work, of which a few have become specialised, as in the case of gold thread enrichments or embroideries. As illustrating the method of stitching down, I have a diagram of Indians at work doing applied embroidery with gold threads.

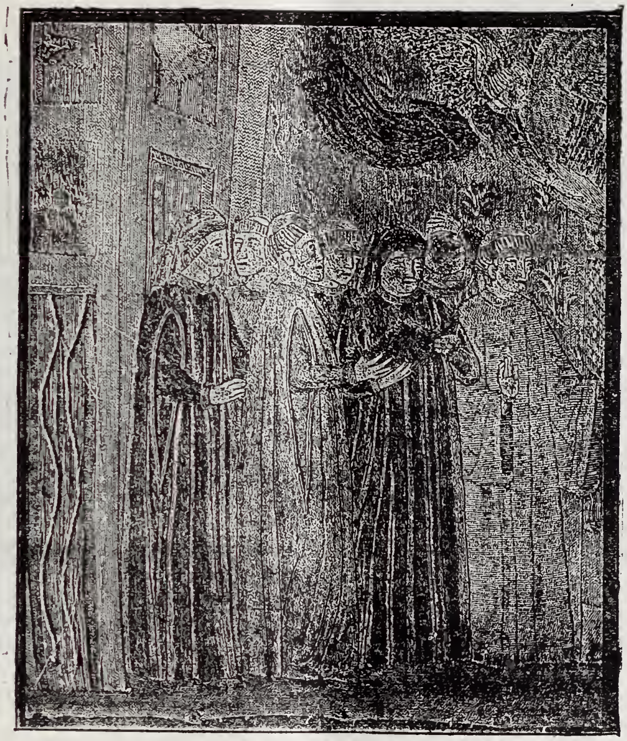
The sumptuous heavy golden trappings and saddle-cloths, canopies or howdahs, are frequently worked with gold threads "couched" or stiched upon a padded foundation or over stout threads. The essence of "couching," so far as needlework is concerned, is the up and down stitching. But it is not merely a question of holding the gold threads upon a surface, by means of such stitches; for "couching" involves display of skill in so taking the stitches (the threads of which show themselves upon the glittering gold threads lying close together) that patterns and diapering effects are produced by them upon the face of the gold threads. This group of Indians is at work upon a material stretched in a frame. The use of the frame for embroidery purposes is a matter which should, perhaps, have been mentioned sooner. The frame shown here is large; very much smaller ones are used by the domestic embroiderer. All embroidery is done upon material stretched in a frame, or held loosely in the hand. Frames are almost always used for *appliqué* work in its various classes, others of which we shall shortly notice. Returning, for the present, to gold thread "couching," we find specimens of such work intermixed with coloured silk embroidery, dating in Europe from the 12th century. Before then, gold threads were used more often for weaving than for embroidery. There are occasional exceptions to such a general statement, but, as a rule, the use of gold threads in embroidery is later than their use as wefts in weaving.

The specimen of gold "couching" of which I have a diagram, is taken from a funeral pall belonging to the Fishmongers' Company. This pall is supposed to have been used at the funeral of Sir William Walworth, in the reign of Richard II. But the character of some of the ornamental details in it gives it a later date, probably by some fifty years at least. A

Pope in the act of blessing is seated upon his throne; on each side of him is an angel swinging a censer. Gold couching, done over layers of threads so as to increase the effect of low-relief, is used for the background and Pope's seat, the censers, and bands upon upon the robes of the figures. The other portions are, for the most, worked in long and short stitches with silk. Another specimen of similar work is to be seen in this portion of a Y-shaped orphrey for the back of a cope. The composition of the crucifixion is almost entirely worked with coloured silks in long and short stitches. Gold thread, to occasionally heighten the outlines of certain details is used. The bordering and the architectural canopy over the saint bearing a chalice are of gold thread couching. This specimen is considered to be Italian or Flemish in origin, and of the early 16th century.

Previously to this class of sumptuous enrichment of ecclesiastical vestments, came that which has been connected with the modern idea of the *opus anglicum*. The peculiarity of this work is thought to have been the use of a chain stitch or split stitch. The diagram now before us is of the celebrated Syon cope, preserved in the South Kensington Museum. The figures are worked in the chain or split stitch. It has been described by the late Canon Rock with very high antiquarian skill. When attributing it to a distinctively English nationality, I do not find, however, that he mentions that similar embroideries as I previously said are to be seen elsewhere, and are traditionally of other nationality in workmanship. Here, for instance, is a smaller specimen, but equally finished, in skill of chain or split stitch work. This is certainly later than the Syon cope. It is probably of early 15th century Italian work. The Syon cope is unquestionably of the 13th century, so, too, were vestments of the Pope's, some of which are preserved at Anagni. The specimen (Fig. 3) before us is taken from a panel about

FIG. 3.



Part of Panel, Embroidered in Gold Threads and Coloured Silks. The draperies and faces worked in chain stitch. Italian; 16th century.

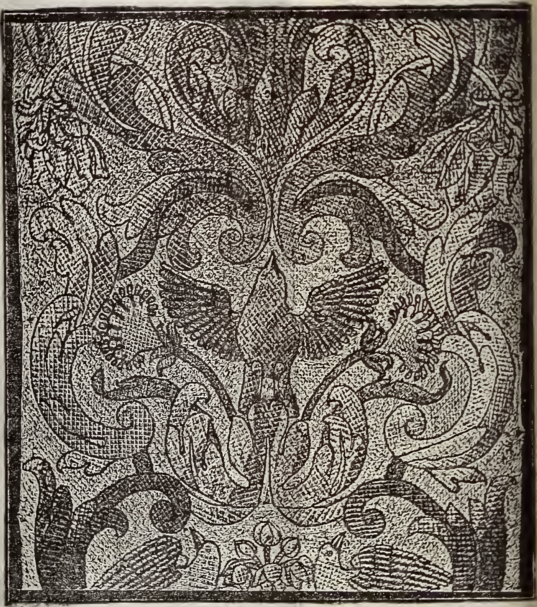
16 inches long by 11½ inches high, in which a female saint is represented at her prayers. A crowd of men are standing behind her near a belfry, and a few of the figures in the group are here shown on a large scale so that the character of the stitchery may be noted. The saint was found by Canon Rock to be Santa Francesea Romana, of whom he recounts saintly and devotional acts. But the present and particular interest of the diagram before us lies in its expounding a skilful use of a supposed typical stitch of the *opus anglicum.* In Persian embroideries, representing hunting scenes, the same sort of stitch occurs, used much in the same way as in this specimen. In Abyssinian robes chain stitch is largely used. The Indians and Chinese have often produced chain stitch work.

For figure subjects this chain stitch in European ecclesiastical embroideries was preceded and succeeded by long and short stitch, the surface of which presented a more painting-like and less granulated effect. This smoother lying stitch was used especially for faces and hands, and we find such treatments in conjunction with draperies, which were rendered by means of fine coloured silken threads whipped around gold threads. A rich golden glow or shimmer pervades such embroideries. Here, for instance, is a specimen of this kind of work, done from a design by Raffaellino del Garbo, in the 16th century. The shading of the drapery is done with blue, red, and green silks, whipped round the gold threads. A golden orphrey is exhibited, as well as a few coloured photographs of some remarkable specimens of this sort of work done perhaps in Spain or Flanders. From the raised "couched" gold thread work we pass to other sorts of "couching," in which the threads to be "couched" are laid flatly upon the under material, no padding being employed. Such work is also frequently done with floss silks, as shown here (Fig. 4). The details are outlined with a thick cord, about the flat couchings of floss silk. This is part of an extensive set of furniture trimmings and hangings, made possibly in Italy or Germany in the 17th century.

The use of cords stitched down to a material, and producing ornamental effect, is exemplified in this jacket of English 16th century. Of a different sort of work, in which long, short, and chain stitches are used, is this jacket, also of English work of the 16th century. The pattern consists, as we see, of an orderly distribution of pomegranates and roses, with slender twisting stems. It is wrought with black silk. This black silk embroidery on white linen, in certain cases, is supposed to be "Spanish stitch," the origin and special intention of which is not known. They furnish matter for antiquarian research.

To return, however, to the flat laying of threads and cord, we may look at a specimen of modern Japanese embroidery. The Japanese appear to excel in skilfully doing the flat gold and silken thread work. The clouds and sky in this specimen are done with gold threads, stitched down to the ground of black. Other portions of the panel are done by means of stuffs and silk cords, and stitched down in portions to padding interposed between them and the black velvet, as, for instance, in these two figures and the trunk of the tree, beneath whose spreading branches the man and woman are watching the approach of message-bearing storks.

FIG. 4.



Embroidery on Linen, with floss silks laid or "couched;" between outlines of black silk cord stitched down to the linen ground.

We noted the use of padding in its connection with the gold thread relief "couching," and now these figures and the tree may introduce us to a class of English work which was done in the 17th century, in which curious modelling effects were attempted by the embroiderer. Intermingled with the relief were portions worked in long and short stitches flatly. Then there were details worked out in needle-point lace stitch. Silks, gold and silver threads, silken and metallic gimps were used. Here is a diagram of such work. Actual specimens may be examined in the room. This sort of work frequently decorated boxes and mirror frames. It was an ingenious, strange, and entirely *malapropos* class of embroidery. Its influence is to be seen in such insignia of state as a Lord Chancellor's bag. The different padded details were, as a rule, worked separately, and then applied to the place assigned to them in forming grotesque compositions upon a ground of silk or satin.

I think there is but one other distinctive group of stitchery which I have not yet named, and that is quilting. In this, again, the essential features are the up and down stitching, and the employment of two bits of stuff through which the stitches are taken. Sometimes, to obtain stronger accentuation of forms, especially in quilted work done with stuff and thread of the same colour, a cord or padding is inserted between the two bits of material to be quilted. The stitches are then taken on each side of the cord or padding, and an effect of low relief is obtained.

But some of the more notable quilting is such as Indians have done with yellow silk on white cotton. This sort of work, usually embellished with sprawling flowers in rich red and gaudy green silks, gold threads "couched," flat, or in relief, was highly prized in the late 17th and during the 18th centuries, by Western Europeans.

More sober in effect, though not, I think, less surprising in workmanship, are the minutely quilted coverlets, or *portiéres*, made in the 16th century at Goa, and largely imported by Portuguese, Dutch, and Spaniards. Here is a small portion of a large quilt of this kind. Hunters, musicians, heraldic bearings, and fleets of vessels are depicted in thousands of minute up and down stitches, with red and yellow silks. The actual quilt is also exhibited.

I had hoped to have been able to have touched more fully than I have upon the use of embroidery in connection with costume. The limits of my lecture, however, prevent me from doing so. Neither can I enlarge upon those fanciful long and short stitch pictures in medallions, frequently done after compositions by Cipriani and Angelica Kauffman. Indeed, the representation of figure compositions by means of embroidery is a subject of itself almost—not, however, from the point of view of stitches that we should find that their production involved any special stitches not already referred to, or that on the whole the process is well adapted to making representations of the human form.

The study of embroidery, even if we restrict it in the first instance as, perhaps, it should be, to examining stitches and the designs they appropriately or inappropriately depict, is wide in scope. It is, of course, essential to those who practice the art from natural inclination or from choice. It becomes simplified, I think, if one takes one thing at a time—as for instance a classification of stitches. The number of typical stitches does not exceed half a dozen, unless it be determined that the smallest variation in length, direction, or arrangement shall be held to constitute a new type—and then of course one may become quite bewildered with hundreds of new names. It is, however, easy, I think, to detect, in the apparently most elaborated of specimens, which of the dozen type stitches have been used, and to form some idea of how they have been used. It is also easy to separate off into another class of operations those methods of using various materials, such as withdrawing threads, cutting out forms, using paddings for effects of relief, couching, &c. Of course, they are all connected with embroidery, but the employment of them, while involving the use of one or other of the few typical stitches, does not create new ones. Having thus assured one's self that there is no cause to become confused by novel applications of well-established methods, one may take up the study of designs in embroidery. Here, I am free to confess that the field is altogether wider, for to intelligently appreciate designs in embroidery, it is necessary to equally appreciate them as wrought in other processes and materials. Moreover, the designer is generally distinct from the embroiderer. Many skilful needleworkers imagine that they are qualified to make patterns; this, however, does not at all follow. For us amateurs, after analysing and classifying stitches, and obtaining an insight into the composition of patterns, no doubt we may feel inclined to consider the historical side of embroidery and the possible meaning of odd old terms; and this is perhaps the more attractive to those who are neither practical embroiderers nor designers. In this respect, I speak for myself; at the same time, I cannot but feel that it is more interesting to try and understand the technicalities of the art, and the constructive meaning of patterns.

I must apologise for the incompleteness of my remarks this evening. I hope, however, that I may have suggested a few topics worthy of your consideration, and whether I have done so or not, I gratefully acknowledge the encouragement in my efforts which your attention throughout these lectures has given me.

[This lecture was illustrated by a series of diagrams thrown upon the screen by means of the electric light.]

Correspondence.

COLONIAL AND INDIAN EXHIBITION.

As you desire to "preserve the names of the many subjects who have come from all quarters of the British Empire to be present at the Exhibition," you may as well have them printed correctly. I give those below which are spelt wrongly in your list of *Indian* names, in the transliteration adopted by the Indian Governments, and to which your informant has evidently intended to conform:—

1.	Shábán	should be	Sha'bán.
2.	Khádim Hosen	,,	Khádim Hussain.
3.	Amiralli	,,	Amír 'Alí.
4.	Emamudin	,,	Imámu'ddín.
5.	Ismail	,,	Isma'íl.
6.	Asgar Hosen	,,	Asghar Hussain.
7.	Nazeer Hussan	,,	Nazír Hasan.
8.	Rahimbrux	,,	Rahím Bakhsh.
9.	Hajee Meahgan	,,	Hájí Miyáhgán.
10.	Nisar Ahmed	,,	Nisár Ahmad.
11.	Mogal Ján	,,	Mughal Ján.
12.	Mohamed Hosein	,,	Muhammad Hussain.
13.	Biláyat Husen	,,	Viláyat Hussain.
15.	Karan Sing	,,	Karan Singh.
18.	Báke	,,	Bákar.
30.	Kádirbux	,,	Kádir Bakhsh.
34.	Kádarbux	,,	Kádir Bakhsh.
35.	Moulabux	,,	Maullá Bakhsh.

I observe that while the *Hindu* names have been given you correctly in the main, all the *Muhammadan* names have been given wrongly. This looks as if your informant had made up the list supplied you from those given him by two writers (*munshis*, as we call them in India), one of whom understood the Hunterian system of transliteration, and the other did not. Nothing can be more confusing or more misleading than the adoption of two methods of transliteration in the same document. I may add that "Meahgan" (No. 9) is not a likely name, and may be for Miyán Ján, a common name. Also I suspect that "Báke" (No. 18) is for Bákar, but it may be for Bákí, an unlikely word in this connection.

R. C. TEMPLE.

Dial-house, Hove, Brighton,
August 14th, 1886.

General Notes.

CONGRESS OF ITALIAN SERICICULTURISTS.—The Second National Congress of Sericiculturists will be held on the 19th of September, at Varese.

SERICICULTURE IN HUNGARY.—Considerable progress has been made of late years in the production of silk in Hungary, and this is due, in a great measure, to the encouragement given by the Government to sericiculturists. In 1884, upwards of 1,620 litres of seeds of the mulberry tree were distributed gratis by the Hungarian government in 2,696 communes, with a view of extending the cultivation of this tree. The production of silk cocoons, from 1880 to 1884, was the following:—

Year.	No. of communes	Quantity of seed silk-worms hatched.	No. of silkworm rearers.	Production of cocoons.
		ounces.		kilogs.
1880..	172	480	1,059	10,131
1881..	423	2,000	2,976	41,557
1882..	433	1,968	3,674	24,455
1883..	462	4,182	6,260	72,242
1884..	557	6,442	9,892	122,123

FIRES IN THEATRES.—At an exhibition of lighting appliances now being held at the Brussels Bourse, M. Léon Lenaerts, of Brussels, shows in action an apparatus for use in cases of fire in theatres. By means of the arrangement, in which electricity aids and supplements gas, anyone is able, on an alarm of fire being raised, to shut off the supply of gas at the meter, thus preventing an explosion, and at the same time lighting up some incandescent electric lamps which direct the way to the exit doors. Thus, an audience seized with panic, would be reassured on seeing the safety lamps illuminated, which would inform them that the gas was shut off, and, instead of being left in total darkness, would be shown the nearest way out. Moreover, if a fire should break out without attracting notice, electrical contact would be made by the insulating substance being consumed from double wires disposed about the building, thus producing the same results automatically.

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FRIDAY, AUGUST 27, 1886.

All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

NOTICES.

EXAMINATIONS, 1887.

The Programme for 1887 is now ready. The Examinations will be held on the 28th, 29th, 30th, and 31st of March. The Practical Examination in Vocal and Instrumental Music will be held in the Society's House during the week commencing on Monday, May 23rd. A copy of the Programme is sent to each institution with this week's *Journal*.

Copies can also be obtained gratis on application to the Secretary.

Proceedings of the Society.

ELEMENTARY LECTURES.[*]

ELECTRICITY.

By Professor George Forbes.

Lecture I.—Delivered April 3rd, 1886.

Electromotive Force and Potential.

The work of the philosopher in studying the phenomena of nature is accomplished by the aid of either observation or experiment. In the science of astronomy we can only wait, watch, and observe the signs and symbols which nature makes to us, and interpret the language in which she speaks. In the realm of electricity, however, we cannot depend much on observation, and it is only in the laboratory by patient experience that most of the secrets of electricity can be evolved. With the lightning flash, the aurora, and the direction of the compass needle, almost the whole list of facts which can be learnt by observation in connection with electricity and magnetism has been completed, and it is by experiment in the laboratory that we must learn how varied are the phenomena, and how fruitful are the applications of this science, while at every step we find new pleasure in receiving answers to our questions. The highest delight of the true philosopher is in seeking out new facts, and the chief charm in electricity to the true student is in grasping the innumerable phenomena which are presented to his senses, and in co-ordinating and arranging these facts, until he finds that a few general laws govern the diverse forms under which this protean agent is seen to manifest itself. It will be my object, in this course of lectures, to lay before you simply the fundamental phenomena of this comparatively new, but useful, servant of ours, and to demonstrate experimentally the identity of the agent, however diverse may be the operations which it may be accomplishing. I trust that you will find it easy to read the language of experiments, and so to grasp those fundamental laws, which govern the numerous applications of electricity, which we meet with every day.

The first electrical fact to be studied is the effect of rubbing together two bodies made of different materials; after rubbing they show a tendency to adhere to each other. They are then said to be electrified. With some substances this is not easily made visible, but with others it is quite evident. Take for example, silk and glass. I rub a dry glass rod with a strip of dry silk, the silk being hung from a support above. After some friction, when I try to withdraw the glass, you see that the silk sticks to it. In frosty weather, when the hair of the head is dry, the friction of a comb will often make the hair cling to it in the same manner. The glass and silk lose the property after a while, but if the air is so dry that no moisture strikes them, they retain it for a long time.

Returning to the experiment, we may easily show something more. Withdraw the glass forcibly from the silk, and the space between them acquires new powers. Firstly, when the glass is an inch or two from the silk, and no sticking can occur, the action of the intervening electrified space causes the silk and the glass rod to approach each other. In the experiment, as now arranged, we can only show that the silk approaches the glass rod; if we suspend the glass rod horizontally, by a thread at its middle, we see that the rod moves to the silk. Of course you notice that for each of these experiments I must first rub the silk and glass together.

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[*] These lectures were delivered on Saturday afternoons in accordance with the resolution of the Council that a course of elementary lectures on electricity should be given before the Society

But the space between the glass and silk has other properties. Here I have a light gilt ball at one end of a stiff fibre of shellac, which is hung by a thread at its middle. My glass and silk being rubbed and placed opposite each other, I hold the fibre of shellac in the hand, and cause the gilt ball to touch the glass rod. I then hold the thread so that the ball is in the space between the silk and glass, and you see the ball which had touched the glass is acted upon by this space, so as to move towards the silk. After having touched the glass, it is acted on by the electrified space in the same way as the glass was in the previous experiment, If now I make it touch the silk, and then hang it up, you see that the electrified space moves it towards the glass. In each case contact with glass or silk causes the space to act on the ball in the same way as on the material touched. We found before that the silk and glass are acted on by the space, so as to move in opposite directions. We now find that after the light ball has touched the rubbed silk or glass, the electrified space moves it in opposite directions. In each case the ball is said to be electrified by contact, but there is something different in the two means of electrifying the ball. We must denote this by some language, so we say the ball is positively electrified if it moves towards the silk, and negatively if it moves towards the glass. It follows from this, that after the glass and silk have been rubbed, the glass is positively, and the silk negatively electrified. We have also learnt that when an electrified body touches another which is in its natural state, it electrifies it in the same way as itself.

If I have two metal balls attached to shellac fibres, and touch the rubbed silk with one and the rubbed glass with the other, the one is said to be positively, and the other negatively electrified. If now I make them touch each other, each becomes electrified, as it were, partly positively, and partly negatively, and they produce no effect. This is seen by hanging one of the balls between the rubbed glass and silk, when no action takes place.

The action of the space on the electrified ball, and on the glass and silk, is the same as it would be if two positively electrified bodies repel each other, and as if two negatively electrified bodies repel each other, and as if a positively electrified body attracts a negatively electrified body. Hence a rule is often given which saves time, viz., "like electricities repel, unlike electricities attract." This is a most unscientific way of speaking, because there are no such things as electricities. Moreover, it is not true that the electrified bodies attract and repel each other. It is the electrified space which acts on the electrified bodies, and makes them act as if they attract and repel each other. All this must be remembered when the above rule is quoted.

I have used a glass rod and a strip of silk in these experiments; other materials would act similarly, though not always with the same intensity. Sealing-wax might be rubbed on cat skin, and the same effects would be observed. The excited sealing-wax, if suspended between the rubbed glass and silk, would move towards the glass. Hence it is negatively electrified. The cat skin is positively electrified.

I must now ask you to observe that when we electrify two bodies by friction, they are oppositely electrified. The most extensive experiments have all gone to prove that we cannot electrify one body positively without at the same time electrifying another negatively to an equal extent. In fact, the only effects observable are those produced in and by the electrified space lying between the bodies which we say are positively and negatively electrified. When I electrify one body by contact with another electrified one, what is given to the former is taken from the latter.

I will now show you two instruments used for detecting feeble electrification.

The first is a gold-leaf electroscope. A rod of metal has a metal knob or a flat disc at its upper end, and two strips of gold leaf hanging from its lower end; let us call them A and B. The leaves are enclosed in a glass jar to prevent the air blowing them about, and the disc is outside the stopper of the jar. I touch the disc with a positively electrified body; the two leaves become positively electrified. There must be somewhere a negatively charged body, which we shall call C. The space which includes the leaf B is electrified owing to the presence of A and C. Thus the leaf B tends to go away from A. So also the leaf A tends to go away from B. Thus you see the two electrified leaves are repelled, and owing to their great lightness, we are able to detect a very feeble electrification.

The second instrument is the quadrant electrometer. I will not now describe the beautiful complete instrument, but will content myself with showing you a simple form which shows you its principle. Here I have a horizontal metal circle cut into four pieces by two diameters. Thus I have four quadrants, A, B, C, and D, each supported on a glass stem.

I rub a piece of glass on a piece of silk and touch opposite quadrants A and C with the glass. They become positively electrified. I touch the other quadrants B and D with the silk. They are now negatively electrified. The condition of the electrified space near the quadrants is such that a positively electrified body tends to go from A or C towards B or D. I now hang a metal index by a silk fibre horizontally over the intervals separating A and B, and C and D. If now this needle gets the feeblest electrification, the electrified space will move it towards B and D or towards A and C, according as it is positive or negative. I may make this instrument still more sensitive by attaching a light mirror to the index and reflecting a beam of light from a lamp on to a scale. The slightest motion of the index is shown by the movement of the spot of light. You see that I have a wire hanging from the index through the centre of the circle and dipping into a glass vessel containing liquid. I will now use this delicate instrument to show you an experiment. I have a piece of zinc and a piece of copper, each fastened to a rod of glass. I bring the zinc and copper into contact for a moment. Are they electrified? Let us try and see. I touch the liquid with the zinc. The index is electrified. The spot of light moves, showing me that the index has moved away from A and C and towards B and D, I now know that the zinc is positively electrified. In the same way we find that the copper is negatively electrified.

With this apparatus I might show you that any two dissimilar substances when rubbed or pressed together are electrified, the one positively and the other negatively. If any two of the following substances are rubbed together, the one first on the list becomes positively, and the other negatively, electrified:—Cat's fur, polished glass, ivory, silk, rock crystal, the hand, wood, sulphur, flannel, cotton, shellac, rough glass, caoutchouc, resin, gutta-percha, metals, gun cotton. I wish to draw attention to the fact, that the order of the objects in such a list does not depend merely upon the material of which the substance is composed, it depends on the character of the surface as well as on the nature of the substance. In the list you will see that the rough glass is put near the bottom and polished glass near the top. I have here a piece of glass which is half rough and half smooth. I will rub this with my silk as before, and according to my list, which we have here, the polished glass comes before the silk, and therefore it should affect the gold leaves in them in the manner represented by positive electrification. When I approach it the negatively-charged leaves converge. I now reverse the end of the rod, and rub the roughened glass, and you will see that, according to our list, the roughened glass will be negative. Now the action takes place on the electroscope, and we get divergence. This is a peculiarity of the surface. We find that the surface has an influence on the character of the electrification. Thus we find that a black ribbon rubbed with a white ribbon is negative to it; we find that a hot piece of cork rubbed against a cold piece of cork is negative to it, and I would point out to you the fact that in all these three cases where the effect of surface comes in, the material which is the best radiator of heat, becomes negative to the one which is the worse radiator of heat. A hot substance radiates more heat than a cold one, and is negative to it; black silk radiates more than white silk, and is negative to it; a rough surface radiates more than a smooth one, and is negative to it. I merely give you this fact as a sort of aid to memory, not the least implying that there is a physical connection between the two phenomena, although it is by no means impossible that there may be something of that sort found later on, because there are some startling connections between heat and electricity.

Hitherto I have dealt chiefly with the electrification of materials which we call insulators, which do not conduct electricity freely. If I rub a piece of brass with cat skin, it has no influence whatever on the electroscope, but it is not because electricity is not generated in the brass. The reason is that brass is able to conduct the electrical condition through my hand and body, and so over the surface of the earth, and if I put the brass itself on a cylinder of sealing wax, which does not conduct electricity freely, then I have no doubt I shall be able to show that when rubbed with cat skin it will be electrified, as shown by the divergence of the gold leaf. I may show this in another way. By striking the brass disc of the electroscope with a piece of silk, you see that the gold leaves are made to diverge.

In the experiments with the quadrant electrometer, you noticed that I used glass supports on three occasions. I put the metal quadrants on glass, I put the liquid in a glass vessel, and I put glass rods on the copper and zinc discs. The reason of this is that glass does not allow the electrical condition to pass along it. You have seen that the electrical condition can leave one body and go to another by contact. When the quadrants were electrified, it would be natural to expect the electrical condition to spread all over the table, and all over the world. It would do so if the quadrants were not separated from the table by a substance such as glass, which is said to be an insulator and stops this action. The silk fibre supporting the index is also an insulator. Fortunately our atmosphere is an insulator, otherwise it would be difficult, or impossible, to show any of these experiments. If the air were what is called a conductor of electricity, it is unlikely that we should know anything of the existence of this wonderful agency, electricity. It is only in empty space, or space filled with insulating material, that we discover the electrical conditions which we have been studying. The following Table classifies some substances as good conductors and good insulators ; most substances are not high-class conductors, and yet are very bad insulators :—

All the metals. Carbon.	Good conductors.
Water and most liquids	Imperfect conductors.
Moist materials generally.	Imperfect insulators.
Dry glass, paraffin, shellac, silk, gutta-percha	Good insulators.

In any atmosphere, except a very dry one, many materials (glass in a most marked manner) receive on their surface a thin film of water or moisture which is a partial conductor. Thus an insulating material may lose its insulating qualities in a moist atmosphere. For this reason, in a moist climate, many experiments succeed best if the apparatus is kept warmer than the air of the room. This prevents the condensation of moisture on their surface.

We are accustomed to say, when we electrify a body in any manner, that the two substances which are rubbed together, after rubbing, have a different electric potential. I shall have to speak presently about what we mean by a difference of electric potential, a thorough understanding of which will help us vastly in our studies further on. I merely remark now that we can obtain very much larger quantities of electrification at these high potentials by means of special machines, like the well-known electrical machine of Mr. Wimshurst, which I shall be using in the course of one or two succeeding experiments. Such an apparatus enables us to get considerable quantities of electricity. I have here a very large and powerful multiple plate machine, most kindly constructed, especially for illustrating this lecture, by Mr. Wimshurst. Mr. Wimshurst has spent a great deal of time in improving the construction of machines for generating electricity. Two or three weeks ago, Mr. Preece and myself were visiting his house, and were struck with a magnificent machine which he had completed, which gave a larger quantity of electricity than any other machine hitherto constructed. A sigh escaped me that I could not produce this machine for the present audience ; but without saying a word to me or anybody else, Mr. Wimshurst, on our departure, set to work to design and manufacture the machine before you, which could be transported from his house at Clapham to the Society of Arts. This machine is the outcome of a fortnight's work taken out of sleeping hours, and this is a piece of kindness for which you and I cannot too heartily thank Mr. Wimshurst.

There is a word which I used just now, and which is continually being used with regard to applications of electricity, and that is the difference of electric potential. I think this is the fitting time to say something more about it, as I have been telling you that two bodies when rubbed together acquire a difference of potential. What do we mean by this expression ? It is a comparatively new expression in scientific language, but one of the greatest importance. We know that the force of gravity gives velocity to a falling body, and the body acquires what we call energy of motion—kinetic energy, it has been called, which means energy of motion. But when a body is raised from the floor on to the table, it is not in motion, because it has the power of dropping back again to the floor, and so doing a considerable amount of work. How are we to express the energy which exists in a ball when placed on the top of a table ? It has a potency of doing work ; it has what Rankine called potential energy, and the word expresses very well what we mean. Suppose a ball to be thrown up into the air; at starting it has kinetic energy—energy of motion; but gradually the energy of motion disappears, and its velocity gets less and less until, at the top of its flight, it has no motion at all. The whole of the energy of motion, with which it started, has been converted into energy of position, due to the greater altitude at which it is. The grand principle of the conservation of energy tells us that at any moment in the history of the universe, the quantity of energy in it is the same, and this is an illustration of a case of conservation of energy, that the sum of the energy of motion, with energy acquired by position, is constant in the case of the ball. You see then what we mean by energy of position, and energy of position is identical with what we speak of as potential energy. If I have a piece of sealing-wax negatively electrified, and a piece of cat skin positively electrified, then to take any substance charged with positive electricity, and carry it from the sealing-wax, which attracts it, to the cat skin, which repels it, I am obliged to do work, just as I am obliged to do work in raising the weight from the floor on to the table, and what we mean by difference of electric potential between the cat skin and the sealing-wax, is simply the work which I should have to do on any substance charged with a unit of positive electricity in moving it from the sealing wax to the cat skin. That is all that is meant by the very common expression, the difference of potential between two bodies, or two parts of a body. Various instruments have been devised for measuring the difference of electric potential. The gold-leaf electroscope, which I am using chiefly to-day as being more handy and convenient in a room where the foundations are not very steady, does not actually measure the difference of potential, but serves to point out whether there is a difference of potential or not. The most sensitive instrument of this kind is the quadrant electrometer of Sir William Thomson.

Hitherto I have been speaking to you about electric forces, the forces with which two electrified bodies attract and repel each other, forces which we can all thoroughly understand as being forces, because we see their effect in the motion of material bodies. I am now going to bring before your notice another kind of force, a force which is not rightly called force in the Newtonian sense of the word. The force I am going to speak of now is usually called by the name of electromotive force, implying that it is a force which moves electricity, not matter; but Newton called force that which causes or tends to cause motion in a material body. When we have seen these attractions and repulsions, we have seen motions given to a material. When gravity is acting on a heavy body it is tending to produce motion, even although the tendency be not allowed to come into effect. In all cases of force, as Newton intended the word force to be used, motion is produced, or there is a tendency to produce it in a body. In electromotive force this is not the case. Electromotive force has a tendency to produce a change in the electrical condition of a substance. This effect is called electric induction. I will show you the production of this kind of force by its action on a conductor. Here I have two insulated balls so connected together that they form one continuous conductor. Of course if I were to take either one towards the electroscope, they would not show any signs of electrification, but when I rub this glass cylinder with the silk, it becomes electrified, and I have already shown that if I were to touch these balls they would become electrified in the same way. Now, I will not touch them, but I will bring them into the neighbourhood of the electrified body. This glass is positively electrified. I say it attracts the negative condition in a conductor towards itself, and repels positive electricity away, independent of any force, as the term ought to be used, on the material body. It is acting on the electric distribution. I will separate these balls while under the influence of the glass, and now I have no doubt that the electroscope will show me that they are charged. One ball, on approaching the electroscope, causes the leaves to diverge more, and the other on coming towards it makes them collapse. Thus we see that not only can electrification produce a visible, tangible effect in the way of motion on a material body, but it is able to create a motion of the electrification of a conducting body, that is to say, it is able to attract a negative electrical condition towards itself, and to repel a positive electrical condition to the most distant part of the conducting substance.

I will now show you one or two of the applications of this principle of induction, as it is called. The first illustration may be given by showing the influence on the gold-leaf electroscope. If I rub the sealing-wax once more it becomes negatively electrified; if I cause it to approach the electroscope, the positive electricity will be attracted to the sealing-wax, the negative electricity will be repelled to the gold leaves, and they repel each other. On removing the sealing-wax, the electromotive force is removed, the electrification returns to its normal condition, and the leaves collapse. Now I will repeat the experiment in a slightly different way, and I will touch the disc of the gold-leaf electroscope with my finger, so that the electricity which is repelled by the sealing-wax may pass through my body to the earth, instead of to the gold leaves only. Now, it has passed to the earth, and the positive electricity is attracted towards the sealing-wax and exists in the gold leaves and their attachment. I remove first my finger and then the sealing-wax, and the positive electricity which existed there is free from the action of the electromotive force, and can spread over the gold leaves, and so the repulsion of the two is seen.

It is due to this induction that the ordinary attractions are manifested. When I have a gilt ball or any light material suspended, and bring an electrified substance near it, the attraction which takes place is only due to induction. The negative sealing-wax draws a positive electrical condition towards it, and repels the negative; the positive end being nearest to the sealing-wax is most attracted, and, therefore, we have attraction, but when once the electrification of the sealing-wax has been communicated to the pith balls by contact, they are then repelled in the ordinary manner. So if I tear up paper into small fragments and lay them on the table, then rub a stick of sealing-wax on my coat sleeve and bring it near the fragments induction takes place and they fly to the wax.

I will now show you several more ways in which induction can be applied. First let me show you the electrophorus. Here is a slab of ordinary resin; by giving it a few brisk rubs with the cat-skin it is electrified negatively. I now place on the top of it a piece of brass sheet having a glass handle. It touches the resin in three or four points, and takes off the electricity from those points. But I will remove that electricity by touching the metal with my finger, and taking that electricity to the ground. Now the parts of the resin which are not in contact with the brass are negatively electrified, and attracting a positive electrical condition by induction towards the lower part of the brass, and the negative is repelled through my fingers towards the ground. The brass is now charged positively, and this fact is shown by the spark which can be taken by my finger when I separate it from the resin. Now I will show you a thing which can be done by means of this electrophorus. Having once more rubbed it with the cat-skin, I can repeat the operation which I did just now, and charge this Leyden jar, and I can go on doing so a great number of times, and this charge is all the time accumulating in the Leyden jar which is capable of being highly charged, and thus by means of going through this operation of induction and communication in this way, I am able to give a very considerable charge to this apparatus, which is called a Leyden jar. It is now sufficiently charged to show you that the accumulated electricity is considerably augmented. When I touch the knob of the jar, with my finger a bright spark passes.

I will now show you what the general principle has led up to in the past. It has led up to the construction of machines of very great simplicity, and probably of very great utility in the future, although we do not see at present many applications. The first machine that was made of the kind was what was called "Nicholson's Doubler," which was simply an automatic means of subjecting a disc to induction, and so electrifying it, and doubling its charge upon another disc, and so multiplying the charge. I will not delay further on this, but simply say that this instrument was invented in 1780, and the little instrument before you is the precursor of, and has led up to, the construction of the magnificent machine of Mr. Wimshurst, the effects of which I will now show you. Here we have a very brilliant apparently continuous blue discharge of the ordinary kind. It is very seldom that such an enormous quantity of electricity has been generated with a machine of this kind. The machine consists of eight plates especially arranged in the most favourable conditions, as it has been developed by Mr. Wimshurst's experience. As I am showing it you now, it is the arrangement which passes the greatest quantity of electricity in a given time—that is, not in the form of a spark, and it does not give the largest noise; but it gives us the largest quantity of electricity that we can get when so arranged. I will now connect two Leyden jars, which I will describe presently, the outside coatings of the Leyden jars being joined to one conductor of the machine, and the insides to the other, and then you will see we get a totally different effect. By introducing these Leyden jars we are able to accumulate in the conductors a much larger quantity of electricity before it is able to escape to the other conductor. The Leyden jars are simply accumulators or condensers of electricity, and they accumulate the electric charge. I shall begin with the poles very close together, and now the electricity cannot pass between those poles until they have acquired a certain difference of potential, and the quantity of electricity generated by the machine is limited, and before it can acquire that potential it has to charge these two Leyden jars. Consequently, with this arrangement of the experiment what we see is a pause, during which nothing happens, then a flash across, and then a pause during which the electricity is accumulating, and then another flash. This is a totally different character of discharge to the former. I limit myself to about a six or seven inch spark, because I do not wish to press the experiment too far at present. I have an experiment which I am anxious to try, but which I have not perfect confidence in, and in my endeavour to show you that experiment at the end of the lecture I shall strain this machine to its limit; possibly the limit will not be the strength of the machine, but the strength of the Leyden jar, and we shall probably find that we actually pierce the glass of one of these Leyden jars. That is very likely to be the case, but it will simply show the power of the machine if it is so.

Having shown you the phenomena of attraction and repulsion, I would ask you whether you feel satisfied with the old view which used to be stated, according to which "electricity is a fluid material which settles upon the surface of an electrified body, and, acting across the intervening space by a kind of action at a distance, causes attraction or repulsion upon other bodies." This is an old question which meets us in dealing with gravitation and other physical forces, and for my own part it is inconceivable that the sun, for example, can be endowed with something like a mesmeric power, by means of which it is able to will the distant earth to approach it; still more inconceivable is it to me, that this rubbed sealing-wax can divine whether another object it its neighbourhood is positively or negatively electrified, and so make up its mind to will that object to approach it or to recede from it. To me the motion of this action at a distance is something so inconceivably absurd, so illogical, and beyond the province of the natural philosopher, that it passes altogether into a pseudo-metaphysical question. It seems inconceivable to me that this action can take place at a distance, without the intervention of some medium between the two mutually acting bodies. The existence of such an intervening medium seems to be essential to any conception which we may eventually arrive at as to the causes of electricity, and the cause of gravitation. Such a medium we are almost certain does exist. The theory of light has almost conclusively proved to us that there is such a medium pervading all space, and penetrating between the molecules of material bodies. Whether or not this medium which produces radiation also produces electrical and gravitational phenomena, I will not venture to assert, but Newton asserted his incapacity of realising the action of force at a distance, and every philosopher, I think, must have the same instinctive aversion to the notion of force acting at a distance without some intervening medium. It was our great philosopher Faraday who realised that all electrical phenomena were produced by an electrification of a medium which fills all space. Is this medium the same as the luminiferous ether? Is electrical induction produced by the same medium as radiation of light or heat? How can we test this? We know from our study of light that the ether is in a different condition in the space occupied by air, from what it is in the space occupied by glass, sulphur, or resin. Faraday asked himself, "Is the induction in a certain space different when different insulating materials fill that space?" He appealed to experiment, and experiment answered loudly, "Yes."

I fix an electrified ball over the disc of an electroscope. Induction takes place through air, and the leaves diverge a little. I now take a cake of sulphur and, after passing a flame over its surface to remove all traces of electrification, I interpose it between the electrified ball and the disc of the electroscope. The leaves immediately diverge farther. The induction through sulphur is greater than through air, clearly showing that induction is due to the action of the intervening medium. This brilliant discovery of Faraday's was very fully investigated by him.

I have spoken about and used the Leyden jar. The Leyden jar consists of nothing more nor less than two conducting sheets of tinfoil separated by an insulating material such as glass; it is made in the form of a jar, because there is less chance of the electricity passing from the outside coating or conductor to the inner coating or conductor along the surface of the glass, and it was first discovered by a glass vessel having been filled with water, which a philosopher was trying to electrify, as he was holding it on the outside with his hands, by making contact with the inside, and he so actually got that shock which you now see me get from the Leyden jar by connecting the inner and the outer coatings through my body. Induction is of course taking place between these two coatings, and the nearer the coatings are together, the greater is the induction, and the greater is the capacity of the jar. By having a thin piece of glass we are able to have a powerful induction, but we must not have the glass too thin, because there is a certain limit to the strength of the glass, and if we exert it too far we pierce the glass and fracture it. The strain of the electrified glass may suffice to break it. But glass resists the strain better than air does. When we use the Wimshurst machine, eight inches of air is not sufficient to resist the strain, while a quarter of an inch thickness of glass in the attached Leyden jars is not pierced. In practical applications of electricity, when we are using high differences of potential, it is important to use, for our insulators, materials which afford a high resistance to this strain. If the glass of the Leyden jar is pierced, the hole which is made is filled with air, the space being only a quarter of an inch thick, so that the spark can pass through that hole and we cannot get long sparks between the conductors of the machine. Now you will notice that this involves the notion of a strain in the glass—that when the two inner and outer coatings are electrified, there is a strain in the glass between the two surfaces. There is a notion which was thought of by Faraday which he developed into the conception as to the nature of induction which is universally held by electricians. He supposed that in these phenomena of induction, and of attraction, and of repulsion, the whole of the action is taking place in the medium between the two conductors. He showed that it was impossible to give an absolute charge of electricity to one substance without giving an equal but opposite charge of electricity to other substances, and there must be lines of induction, a course of induction between two electrified bodies which are separated by an insulating medium such as air. His notion was that we must abolish the idea of a body being charged with electricity; we never find proofs of electrification in equilibrium except in the medium which is an insulator, and on that part of the insulating medium which forms the boundary of the conductor. In order to illustrate that, I will show you an experiment with a Leyden jar which is in pieces, and capable of being separated. Faraday's view was that it was wrong to speak about the conductors being electrified; that the whole of the phenomena is in the glass, and it is the retaining of the medium by this new inductive action which produces the whole phenomena of electricity. I will now show you that Faraday's view was so far correct that the charge does undoubtedly exist in the glass, and not in the electrified conductor. I remove the inner and outer coatings from the Leyden jar, and touch the electroscope with them to show that they are not strongly electrified. I now replace them, and I think now I shall be able to get a spark from the Leyden jar—Yes! a feeble one. I have discharged the outside and I have discharged the inside, but I have left the glass strained as Faraday said it was strained, and after putting its inner and outer coatings on once more, I am able to get a spark from the glass which continued to possess this strain.

Now, if it is a case of mechanical strain, a material which is once strained takes time to get rid of its strain, and here is an experiment which will show how this is the case. You see I can get a spark from this Leyden jar, though I had a little time ago discharged it. So here again, I am getting up an excitement in the machine, and then I will discharge it. The poles of this machine are connected with the Leyden jars; I will discharge the Leyden jars so that no more charge exists; but the glass in these Leyden jars is twisted, and is gradually untwisting itself, and as it untwists itself it developes the electric condition, and now I think I shall get another discharge. [A very feeble spark was shown.] Sometimes I can get a considerable number of discharges in that way. I will show you that by the aid of a piece of material which Mr. Wimshurst has kindly given me, which is called dermatite, the constitution of which I do not know. I will charge myself while standing on it, and show you what a long time it takes for this dermatite to get rid of its strain. I am now pretty well charged, and now we will see if Mr. Davenport can take a spark from my fingers. [Nine successive sparks, the last very feeble, were produced.] Had it not been for that material taking a long time to get rid of the strain, the first discharge would have completely discharged the electricity in my body, but owing to the peculiar construction of the material, probably made of layers of different insulating powers, it takes a long time to get rid of the strain which has been induced in it, and so the successive discharges are shown as the strain is gradually given off.

Now I will mention a very striking experiment to show that this induction is really a state of strain, which Quincke made many years ago. He took a residual discharge from a Leyden jar electrified, that is he first discharged it, and then after a little time showed there was more to discharge. He had a delicate electrometer to show the rate at which the strain of the glass was giving way, the rate at which a difference of potential was being created between the inside and outside coatings of the Leyden jar. Then he simply tapped the Leyden jar gently; what would be the effect of that? If this glass were strained we know that tapping it would make it get rid of its strain. In doing so, while he was measuring the electricity from the residual charge, he trebled the quantity that was being given off, simply by giving a mechanical tap which enabled it to get rid of its mechanical strain easier. I think this is almost conclusive proof that the induction which takes place is only a case of mechanical strain. This is the theory which was enunciated by Faraday, a theory which was worked out more fully by Clerk Maxwell. Clerk Maxwell showed that if we supposed the medium air, or whatever it is, to be exerting tension along the direction where induction is taking place, and exerting pressure at right angles to that direction, the whole phenomena of induction, and of attraction and repulsion, and all the phenomena of electricity in equilibrium, can be thoroughly explained in that way. It would be, therefore, necessary not only to prove that there is a state of strain, but also that this is the direction of the strain. This is the brilliant experiment which was accomplished by Dr. Kerr, of the Normal College, Glasgow. I am afraid it is hopeless for me to attempt to show it to you; it is an experiment which has only once or twice been completed. It is so very important to show you an experiment which has actually proved to us that the theory of Faraday, as worked out by Clerk Maxwell, was true, namely, that the strain of the insulating medium is in a certain direction, that I did want to show it to you, although there is some difficulty in doing so. I will show you the form of the apparatus, at any rate, and then I will do my best to show you the result which Kerr got. Here is an electric lamp, by means of which I can throw a beam of light on the screen. I have an instrument here which is called a Nicol's prism, by means of which the light which passes through it, is polarised; that means that all its vibrations are in one direction, in this case, up and down, we will say. Further on there is another Nicol's prism, through which the light has to pass (and I have to thank Dr. De la Rue for his kindness in lending such a magnificent piece of apparatus, to try and show you this experiment. This Nicol's prism is a most rare piece of crystal work.) This is a Nicol's prism which does not allow any rays of light vibrating in the direction I have spoken of to pass through it, and, therefore, when we have arranged these Nicol's prisms in such a way that the one cuts of the light from the other, we shall see no light on the screen. I now place a vessel containing bisulphide of carbon, in the focus of the lens, between the two Nicol's prisms. In that vessel I have two glass tubes, with bulbs at their ends, filled with mercury. There are wires proceeding from the mercury and attached to insulating wires which go to the conductors of the large Wimshurst machine. At this moment the Nicol's prisms are arranged to produce darkness. I twist one round first to allow the light to pass through, to show you the two bulbs filled with mercury. By twisting the Nicol's prisms round to its former position, I can produce complete darkness. If I were to introduce into the position between the prisms any transparent substance in a state of strain, it has the power of restoring the light to the central part. Now the brilliant experiment which was performed by Dr. Kerr was to charge these bulbs powerfully with a large difference of potential, and then he was able, finally, to see the light on the screen, and the position of the prisms which gave the greatest effect proved the direction of the strain to be as predicted. There is far too much stray light going about for the experiment to be seen. I will now devote my attention to the large machine, and we will try and puncture one of the Leyden jars. Here I have some pieces of glass which have been fractured by the passage of an electric spark through them, showing the enormous tension, enormous state of strain, into which the glass has been put by the difference of potential at its two surfaces Here is a piece one inch thick, which has been pierced by the difference of potential existing between the poles of the great Spottiswoode induction machine constructed by Apps. I have another small piece of glass with a much cleaner puncture through the centre, showing the great strain to which it was subjected. From Kerr's experiment we learn that the electrical strain in an insulator is the same as Clerk Maxwell has shown was to be expected. Now, in conclusion, I will disconnect that arrangement, and simply work the machine in order to show the immense power it possesses, and the piercing of a Leyden jar by the spark.

Miscellaneous.

COLONIAL AND INDIAN EXHIBITION.

A record of some of the chief picturesque and instructive features of the Exhibition is about to be issued under the title of "Reminiscenses of the Colonial and Indian Exhibition." The work will be edited by Mr. Frank Cundall, and will contain coloured plates and etchings by Mr. Thomas Riley. It will be printed and published by Messrs. Clowes and Sons.

The number of visitors to the Exhibition for the week ending August 21st, was 210,303; making a total since the opening of 2,821,706.

PIG-BREEDING IN DENMARK.

In a recent report of the American Consul at Copenhagen, some particulars on the question of pig-breeding are given. In the first place, with regard to the feeding of pigs, it is pointed out that these animals devour their food with great rapidity. The front teeth only do the duty of picking up the food, the side teeth, from their particular formation, being unable to masticate it sufficiently or to mix it with saliva; it is, therefore, important that in order that the required amount of nourishment should be derived from the food, that it should be given in an easily digested form. It has been found that corn when given to swine in its entire state, is passed away in an undigested condition to the extent of 50 per cent. In preparing the food, it is important that it should be first boiled or steamed, and if this is not possible, the corn, &c., should either be ground or bruised, or allowed to soak before use; if roots, they should always be cut into slices. To what extent it is necessary to resort to extraneous kinds of fodder must of course depend upon the farmer's own supplies. It may be noted, however, on the authority of the report, that maize or rice meal, mixed with potatoes or roots, and especially when a small quantity of animal matter is added, has shown strikingly favourable results. Linseed cake is very useful for pregnant or sucking sows, as well as for young pigs, as it assists in the production of milk. Animal food, owing to its richness in albuminous matter, thereby promoting rapid growth, is also recommended for pig-breeding; but this food should be given with a sufficient quantity of other feeding stuffs, free from nitrogenous matter, so that the food may be rendered easy of digestion. As regards farm produce, the report points out that both oats and barley, as affording a wholesome diet, are of great importance as food for swine, whilst oats especially will be found to have a very favourable influence on sow's milk. Peas are also highly estimated, but it is advisable that they should be first allowed to sprout, then dried, and afterwards bruised. Great care must be taken when feeding with husk cereals to watch the animals closely, as such food is difficult of digestion, especially by the young pigs. The sows should never be fed with it as it operates injuriously on the milk organs; sucking pigs are also liable to obstruction from this food. In respect to the various kinds of roots, the report points out that potatoes are most to be recommended, but they should never be given when sprouting, as the sprouts contain narcotic matter injurious to digestion, and when taken in large quantities are found to be poisonous. The results of several experiments in Denmark show that it is more advantageous to feed with boiled than with raw potatoes. Last year ten young pigs from the same litter were divided into two groups when they were 2½ months old, of which one lot was fed with boiled and the other with raw potatoes. Each group received in addition 2½ lb. of barley, which to the first was given in a boiled, and to the other in a bruised shape. Three months later, the increase in the weight of the pigs which had been fed upon boiled food was 173 lbs., whilst those of the other group was only 115 lbs. Apart from the question of feeding, great attention should also be devoted to the care of pigs; the main point is a careful regard to the skins, as a sound state of the skin tends to maintain the activity of all the internal organs. That pigs are greatly improved by cleanliness will soon be shown in their general appearance and fineness of their bristles. Experience has long shown that food is more profitably consumed by swine kept clean than by those uncared for. The report sites the following example in Denmark. Six pigs of equal weight were fed for seven weeks on a uniform diet, three of them being daily kept clean with a comb and brush, and the other three being left in an unclean state. The result showed that each of the clean pigs had increased by 30 lbs. more in weight than the others. On one farm in Denmark, where pigs were daily washed, there was not a single case of hog disease during three years, although it was very prevalent in the neighbourhood. The report points out that the styes should be so constructed that the pigs can feel perfectly comfortable in them, for then only will they thrive. The stye should not be exposed too much to the cold winds, nor to the heat of the sun. The temperature of the stye should be kept, as near as possible, between 8° Réaumur to 12° Réaumur (50° to 59° Fahrenheit); too great heat is liable to bring on blood disturbance, and when the stye is too cold the pigs require too much food to keep up the necessary warmth of the body. Rats are frequent visitors to styes, and are a great source of trouble, and are stated to have been one of the causes of the outbreak of the trichina disease; all possible means should, therefore, be adopted to get rid of these pests, and one of the best is by constructing the floor in a solid manner with bricks and cement, and on no account with wooden materials, which rapidly decay. It appears from this report that in Denmark the breeding of pigs is very intelligently managed, and is making considerable progress.

ITALIAN SILK WEAVING INDUSTRY.

The Como Silk Weaving Association has recently expressed its views as to the modifications which are called for in the National Customs' tariff; this communication being in answer to the inquiries made by the state authorities engaged in framing a project of general fiscal reform. Though no marked increase in production has taken place, still it is urged that the quality of the wares manufactured has improved to such an extent within the last ten or twelve years as to warrant the high estimation in which Italian silk goods are now held in foreign countries. Amongst the reasons assigned for the slowness of industrial progress (as to the amount of out-turn) are the want of power-loom factories for low-priced mixed goods, and the absence of union between the respective manufacturers. Moreover, the total production is not of sufficient importance to allow of the facilities enjoyed by other industrial centres as regards dyeing, finishing, printing, and other subsidiary processes.

With the object of promoting the silk industry on the large scale which can alone render it a success, the suggestion is made that all machinery connected with that branch of manufacture should be allowed to enter Italy free of duty. There being no power-loom makers in the country, no domestic interests would thereby be affected, but in view of the possible creation of such a branch of labour, it is proposed that the new measure should at first be enacted for a limited number of years. It is further suggested that power-loom factories, exclusively devoted to the manufacture of silk goods or to operations connected therewith, should be exempt from the manufacturing tax at present in force.

A statistical return for the years 1880 to 1884, shows that the exports of pure silk goods have nearly doubled during that period, while the importations have increased by only 20 per cent. The exports of mixed goods have not been of sufficient importance to afford reliable comparative data. The imports of the latter are, however, twice as large as those of pure silk goods, and it is in favour of this branch of the trade that protective measures are suggested. At the same time the free admission of all classes of cotton yarn used in the silk manufacture is advocated as a measure which should be applied to the whole production of this class of goods, and not only to the small portion which is exported, so that the free admission might be permanent instead of being temporary, as it is in France with respect to certain counts.

RUSSIAN DOMESTIC INDUSTRIES.

Consul General Swann, of St. Petersburg, in his report to the United States Government on the domestic industries of Russia, says that one of the most interesting groups in the list, and one that is most easily found by the wayfarer, is that of weaving. This industry gives employment to the greatest number of domestic labourers, the larger proportion of whom are females. In some districts weaving is done by families under most adverse circumstances, as in the case when the raw material has to be purchased. In the greater number of instances, however, the articles manufactured are of hemp, flax nettle, hair, and wool yarns spun from home growths after having undergone preliminary domestic preparation. In domestic industries of this nature the products are intended exclusively for home use, and it is only under exceptional circumstances that such wares are taken to the bazaars or market. It is under such conditions that most of the home industries are conducted in the agricultural or blackearth zones, and in the Steppes. For example, the government of Poltava is noted for its excellent linen, and the towels woven in that region with the interwoven eagle and other patterns in red are highly appreciated and difficult to obtain. In the Tchernigoff and Kharkoff governments the patterns woven in wool are chaste and elegant in design, as are also the various handkerchiefs and shawls produced by home industries. The dyeing of the materials for these weavings is a part of the home occupations, as is also the gathering of the various vegetable and other products mostly found in the neighbourhood, and used for staining the yarns, &c. Altogether different in character is the nature and scope of the weavings produced in the governments of Moscow, Vladimir, Yaroslaff, Iv.r, and the northern districts of Kalouga and Toula, where the land is more or less sterile. The nature of the weaving has undergone a change, and has become an industry in its near approach to manufacture. In the Tersk and Dahgestan districts of North Circassia the home weaving of cloth has developed with the increase of population, and this form of domestic industry has grown very considerably since the annexation of Circassia by Russia, as the women have found it possible to give to their domestic industries greater attention than was possible in the days of petty feuds and marauding expeditions, and by maintaining a greater number of sheep it has been possible to obtain the wool necessary for the weaving industry. At present, women only are engaged in the weaving of Circassian cloths, which, in 1881, was represented by 42,422 domestic looms, having an output of 250,965 pieces of cloth, valued at about £200,000. The annual value of the output of the domestic weaving industries in Russia has been estimated at about £4,500,000.

ANIMAL PRODUCTS OF THE CANARY ISLANDS.

The domestic animals of this archipelago embrace a few cattle, plenty of pigs, coarse-woolled sheep, rabbits, and fowls, as well as a locally peculiar, and renowned race of goats, whose milk furnishes a supply of butter and cheese. But the fish harvest affords the chief supply of animal food, and occupies the attention of a large proportion of the population, occurring especially on the African coast. The following kinds of fish are met with:—*Abadejo* (*Serranus fuscus*); *abriote*, a variety of *abadejo*, met with in immense numbers on the African coast, attaining a weight of 30 lb., and of excellent flavour; *bosinegro* (*Pagrus vulgaris*;) *cherna* or *cherne* (*Perca cernua*, resembling, but inferior to, Newfoundland cod; *chopa*, a kind of sea bream, which is extensively eaten both fresh and salted; *corbina* (*Corvina nigra*), weighing 30-45 lb., and caught in the channel between the islands and the African coast; *pezrey* (*Temnodon saltator*), having an average weight of 20 lb., very plentiful about Fuerte Ventura; *rubio* (*Trigla lineata*); *sama* of various kinds, as *Serranus acutirostis*, very common, large, and fine eating, *Dentex filosus*, and *Pagrus auriga*; *sama dorada* (*Dentex vulgaris*); *sama grande* (*Chrysophrys cœruleosticta*), reaching 40-45 lb.; and *tasarte*, said to resemble salmon. Mention may also be made of the cuttle-fish, captured for food, and eels, the latter being the only representative of fresh-water fishes.

Fish are taken by hook and line, and in nets. A system prevails of trolling a number of hooks attached to lines running at right angles between the vessels. Curing is done with salt, and occupies about ten days. The bait is now chiefly herring, which is exceedingly abundant at certain seasons, and taken in seine nets; formerly, octopus was used, and had to be purchased from Moors on the African coast.

General Notes.

Industrial Arbitration.—The French Minister of Commerce has drafted a measure for organised arbitration with a view to the prevention of strikes. The party desiring to refer the dispute to arbitration would make a declaration to that effect before the mayor of the district. This municipal official would then notify to the other party the request for arbitration, in order that arbitrators might be chosen by both. If one of the parties refused to agree to arbitration, the mayor would draw up a document recording the fact and motives of the refusal. This document would be forwarded to the party claiming arbitration. Where both parties would have agreed to arbitration, the judgment of the arbitrators would be drawn up in duplicate. One copy would be given to the parties interested, and the other would be sent to the Ministry of Commerce and Industry, who would thus group together the decisions. These would be useful to indicate the tendency of commercial jurisprudence, and would be available for consultative reference in future arbitrations.

Metropolitan Railway at Madrid.—A Madrid newspaper, *El Imparcial*, states that the project for constructing a metropolitan railway at the Spanish capital has recently been made. The principal network would consist of three double lines of railway, starting from a central terminus, which would be established at 10 metres below the level of the ground near the Puerta del Sol. The first of these branch lines would leave the northern railway station, passing underneath the Place St. Martial, Church of St. Martin, and the Puerta del Sol; its length would be 1,800 metres, all of which would be in tunnel, with a rise of 25 per 1,000 (1 in 40) for its whole length. The second line, which would be 2,000 metres long, of which 1,400 metres in tunnel, would start from the southern railway, and after passing the Prado, Atocha, Las Delicias, would reach the central station with a continuous uphill gradient of 15 per 1,000 (1 in 66⅔). The third branch would start from the station of Las Delicias and pass underneath the Toledo and Matadero gates, Cebada market, post-office, &c., its length would be 2,200 metres, of which 1,800 in tunnel, and gradient 22½ per 1,000 (1 in 44·44). The total length of the three lines would be 6 kilometres, of which 5 in tunnel, and the estimated cost 25,000,000 of *pesetas*, about £1,000,000 sterling. The tunnels would be ventilated by means of three powerful fans, driven by steam-power, established one at the entrance of each tunnel and from the end nearest the central station. Lifts would be provided at the various intermediate and terminal stations for the convenience of the passengers.

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Proceedings of the Society.

CANTOR LECTURES.

THE MICROSCOPE.

By John Mayall, Jun.

Lecture I.—Delivered November 23, 1885.

Origin of the Microscope.

The authors of text-books on the microscope are almost unanimous in implying that we cannot justly claim the microscope as a distinctly modern invention, but that we owe it—at least in its simplest form, *i.e.*, as a magnifying lens—to the ancients, who, if they did not directly transmit the instrument to us, so far notified it in their writings that we are bound to admit our obligations to them, and the utmost we can justly claim is the re-invention of the instrument, and its greater perfection.

I venture to express my disagreement from these authors. After much consideration I have come to the conclusion that the microscope, as we know and employ it, is essentially a modern invention, hit upon, it may be, accidentally, but hit upon at a period corresponding almost marvellously with the advent of the spirit of modern scientific research, when the need of such an instrument was, so to speak, most intensely felt by those precursors of modern science who first struggled out of the meshes of the ancient empirical methods into the free air of experimental methods.

In assisting at the collection of a large number of the microscopes here exhibited, and, indeed, during several previous years, the evolution of the modern microscope has been a subject of special interest to me. Gradually a conviction has been formulated in my mind that the historians of the microscope have been on the whole too ready in tracking the invention of the instrument to ancient times, too anxious, as it has seemed to me, to claim antiquity and a continuous history for it. I must, of course, except Prof. Harting, of Utrecht University, from any criticism on this point, and must acknowledge the fairness and conspicuous ability with which he has sought to exhibit a general sketch of the history of the construction—a history which will be a landmark as long as the microscope is used as an instrument of research.

The question of the antiquity of the use of magnifying lenses was much discussed in former times, notably by La Hire, Molyneux, Fontenelle, Vettori, Robert Smith, Lippert, Dutens, Lessing, Priestley, Montucla, and Lalande. By the diligence of these writers the various passages from ancient authors were collected and submitted to criticism, not always, as it would seem, in the spirit of candour. More recently, Wilde, Arago, Libri, Harting, Poggendorff, and others, have discussed the subject, dealing more or less with the original texts and the reasonings based upon them by modern critics.

The original discussion was revived by M. T. H. Martin, in 1871, in his elaborate paper, "Sur des instruments d'optique faussement attribués aux anciens par quelques savants modernes," in the "Bulletino[*] di Bibliographia e di Storia delle Scienze matematiche e fisiche," of Rome in which the original texts are minutely discussed; and his conclusion is, that magnifying lenses were not known to the ancients, or, at least, were not used by them for any practical purpose. As my own views agree in the main with those of M. Martin, I have thought the present a favourable opportunity to summarise his paper in translation, using the materials collected by him, and the inferences he based upon them, in my own way, abbreviating his text or adding to it. The student should, of course, consult the original for the details of evidence; what I here give is but a rough outline.

In Aristophanes' comedy, "The Clouds," Strepsiades is introduced as a worthy disciple of the subtlety of Socrates, by proposing a new method of escaping the payment of his debts, namely, to hold in his hand a transparent crystal, such as were then obtainable at the apothecaries, and which, in the words of the play, were used for lighting a fire, and placing himself at a distance with the crystal exposed to the sun, at the moment when the public officer is writing on the wax tablet the declaration of the debt by the creditor, he will efface the writing by melting the wax on the tablet. This passage is sheer ridicule, composed in a spirit analogous to that of our own Swift when he introduces us to the professor in the Grand Academy of Lagado engaged "upon a project for extracting sunbeams out of cucumbers, which were to be put in vials hermetically sealed, and let out to warm the air in inclement summers." That it is sheer ridicule is evident, for it is of a piece with a previous passage, where the same Strepsiades proposes to escape the monthly payment of the interest on debts, legally payable then at the time of new moon, by buying a sorceress from Thessaly who should shut up the moon in a box, and so prevent the arrival of the dreaded date of settlement. From such a passage, then, no serious inference can properly be made that the use of magnifying lenses was known to Aristophanes, upwards of 400 years B.C.

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[*] IV., May and June, 1871.

The elder Pliny mentions that physicians cauterised by means of a globe of crystal (*crystallina pila*). He does not inform us whether the globe was solid or hollow, though elsewhere he speaks of a globe of glass (*vitria pila*) filled with water and used likewise for cauterisation.

Alexander, the commentator on Aristotle's "Meteorology," mentions that objects may be ignited by the heat of the sun passing through "a vase filled with cold water, without warming the water in the vase," or at least without warming it sufficiently to account for the fire.

Philopon, the Greek commentator on Aristotle, Lactantius, and others, state, with more or less erroneous explanation, that water exposed to the sun will produce fire.

These citations prove that the ancients knew the effects of burning-glasses acting by refraction, though of the explanation they knew little or nothing.

One ancient author, however, appears to have suspected the real nature of the phenomena—the optician Damien, disciple of Heliodorus Larissus. He refers to concave mirrors burning by reflexion, and then speaks of burning-glasses acting by refraction, stating that through these glasses rays refracted and converging towards the same point ignite objects of a suitable nature placed there. But he gives no theory of this convergence, and says nothing of the form of the glasses, or of their curvatures.

Nothing in the authors cited would indicate that they had any suspicion that these burning-glasses, acting by refraction, could be employed as magnifying lenses.

With reference to the texts of ancient writers where the magnifying power is alluded to, Seneca (in the often cited passages from his "Quæst. Nat." I., 6, § 5) states that "letters, though small and indistinct, are seen enlarged and more distinct through a globe of glass filled with water," and that "fruit appears larger* when seen immersed in a vase of glass;" whence he concludes that all objects seen through water appear larger than they are. Similar statements appear in the writings of Philo Judæus, Ptolemy, and others, down to Aulus Gellius. Seneca adds that "through water we cannot see objects accurately, nor assign to them their true situations."

Several passages might be cited from Archimedes, Ptolemy, and others, to show that though they knew something of the action of refraction at plane surfaces as of water, yet of the refraction at curved surfaces they had no conception. These writers do not appear to have thought that the form of the refractive body was of special importance; they refer indiscriminately to the spherical form, or the disc, or the plane surface of the water, but not one of them speaks of the lenticular form. The passages where magnification is alluded to, show that they attributed the effect wholly to the nature of the water, or again to the nature of the glass or of transparent bodies in general, and never to the geometric forms or to imperfections in the curvatures of their surfaces.

Further, we do not find in any ancient author mention of spectacles for long or short sight, or of magnifying lenses or microscopes. They mention mirrors burning by reflexion, and other instruments burning by refraction, consisting generally of spherical vases filled with water. Occasionally they speak of solid globes, and in one case the discoid form is mentioned; but in view of the notions they held with reference to vision through transparent bodies, it cannot properly be affirmed that they really touched upon the theory of dioptric lenses, or that, in view of the fact that they regarded the process of magnification as being in the nature of the refracting substance without reference to the geometric form, they were on the right track to discover the scientific use of optical instruments.

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* Prof. Baden Powell remarks that "the dependence of this [magnification] on the lenticular form of the glass seems to have been wholly unknown; and this case was confounded together with others, in a way evincing a total absence of all conception of the cause." "Hist. of Nat. Philos.," p. 67, Lardner's "Cabinet Cyclopædia." (1834).

Assuredly, if such instruments had been known to the ancients, Pliny and others would have mentioned them. Certain authors treated specially of optical phenomena, for instance, Aristotle and his commentators on meteorology; in the problems of Aristotle, and the Greek physician Alexander, relative to myopia and presbyopia; in the dissertation of Plutarch on myopy; in the chapters of Pliny on the sight, and on the diseases of the eyes and their remedies; and certainly in the texts of the Greek physicians on the same subject, from Hippocrates to Galen, and from Galen onwards; and in those of the Roman physicians, from Celsus and Aurelian to Theodorus Priscian and Marcellus Empiricus. But no allusion is made to any of these instruments by these authors, nor by any other Greek or Latin author. On the contrary, we find in several writers of the early centuries of our era, texts which are irreconcilable with the hypothesis of the former existence of these instruments. In the 5th century of our era, the Greek physician Actius has nothing to say regarding myopy, further than that it is incurable; and similarly, in the 13th century, the Greek physician Actuarius alludes to myopy as an incurable infirmity of sight, for which art can do nothing. But since the closing years of the 13th century, that is to say, since the invention of spectacles, they are referred to in the medical treatises, and in other works.

It is unquestionable that the ancient artists have left us works, such as gem-cutting, of extremely minute execution, and many modern writers, as Vettori, Dutens,* and Lippert, have insisted that they could not have been produced without the use of magnifying lenses. Natter and Priestley think that they must at least have known the use of globes of glass, such as Seneca mentioned. But by reason of the distortion which so rude a contrivance would produce, it is hardly possible that it could have been employed. Engraved gems have been mentioned, and ivory carvings, in which the workmanship was said to be too small to have been produced by the unaided sight. In the case of one statement of Dutens (2nd ed. II., p. 224) where reference is made to a seal in the Cabinet of Medals, in Paris, said to have belonged to Michael Angelo, and to date back to remote antiquity, on which fifteen figures were engraved in a circular space 14 mm. diameter—"figures .... not all visible to the naked eye," Mr. Philip Gardner, of the Medal Department, British Museum, has made on my behalf a special inquiry of M. Chabouillet, Director of the Cabinet of Coins and Gems, in Paris, who answered under date the 20th inst. (November, 1885), that it was an error on the part of Dutens "(1) The gem is not antique, *i.e.*, Greek or Roman; (2) it never belonged to Michael Angelo."

Then we have the statement of Pliny, that Cicero had seen a manuscript of the whole Iliad contained in a nutshell. But the ancients themselves may have exaggerated somewhat in speaking of their skill in the execution of such curious work. We need not deny that very minute work was executed by them. But in order to rebut the conclusions that have been deduced from the fact that minute work was produced, it may suffice to note that Pliny, Solinus, and Plutarch, allude to these marvels of workmanship for the purpose of proving by the examples of the artists who executed them, that certain men are naturally endowed with a quite exceptional power of vision. Pliny adds that the more minute portions of these sculpturings "cannot be discerned by ordinary men." Hence it is clear that neither the authors nor the admirers of these minute *chefs-d'œuvre* knew the use of magnifying lenses.

Mr. Murray, of the Gem Department, British Museum, informs me that in his opinion there is no engraved work in our national collection that can be affirmed to be antique, and that is beyond the power of the unaided vision of the specially qualified modern engraver.

In reply to Lippert, who insisted that some of the antique work could not have been produced without the use of magnifiers, Lessing says that, by the admission of trained gem-engravers, everything of this kind that can be done with a magnifier may be done equally well, if not more easily, without.

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* Dutens, "Recherches sur l'origine des découvertes attribuées aux modernes," Paris (1766). Poggendorff remarks that although Dutens cites many alleged modern discoveries in physics that were known to the ancients, yet he does not adduce a single example of a discovery in physics by the ancients that was unknown to his contemporaries. Hence Dutens asked his contemporaries to subscribe to the very singular coincidence that the ancients knew just as much of physics as was known in 1766, but no more. "Geschichte d. Physik," Berlin (1878). I quote from the French version (Dunod, Paris. 1883), p. 3, of this excellent work. which has had the advantage of annotations by the translators.

Galen states that an artist of his acquaintance had made a seal, on which was engraved the figure of Phaeton in a chariot drawn by four horses; the mouths, the front teeth, the reins, and the sixteen feet of the four horses were all shown. "As for me," says Galen, "I could not at first perceive all these details, because of the extreme minuteness, except by turning the object towards a very strong light; even then I could not distinguish everything, and many persons were like myself; but when we could distinguish any part, we were agreed that it was executed with the greatest perfection." By these expressions of Galen, it is clear that neither this learned physician, nor the artist, nor the other persons who examined the seal in his presence, knew the use of magnifying lenses; and surely this must have obtained likewise among his contemporaries.

Pliny, who gives us a multitude of details on the processes employed by the ancients in engraving precious stones, who has even told us of the methods adopted by the engravers to strengthen their sight, and who informs us that to repose their fatigued eyes they looked at emeralds or green scarabæi; Pliny, the industrious compiler of the practical knowledge of antiquity up to his date, would not have failed on this occasion, or in speaking of the uses of glass, crystal, and transparent stones, of which he treated at considerable length, to refer to the use of dioptric lenses by engravers if they had employed them. The silence of Pliny, and of the learned Greek physician, Galen, demonstrates conclusively that in the first and second centuries of our era the use of magnifying lenses was unknown to the Greeks and Romans.

Is it possible, indeed, that if the ancients had ever invented telescopes or microscopes, or spectacles for long or short sight, such inventions would have wholly disappeared from the hands and memory of men? As a matter of fact, the employment of these instruments is found only where they have been introduced in modern times by Europeans since their invention in Europe.

The invention of spectacles for long and short sight is referred to as a quite recent invention in a MS. dating from Florence in 1299.* Bernard Gordon, professor at Montpellier, in his *Lilium medicinæ*, commenced in 1305, mentions spectacles as an aid to defective sight. Giordano da Rivalto, in 1305, says the invention dates back only "twenty years." They were, therefore, invented about 1285. It is known that they were invented by the Florentine Salvino d'Armato degli Armati, who died in 1317. He kept the secret with a view to profit by it. But Alessandro della Spina, of Pisa, who died in 1313, having seen spectacles made by Armati, and having succeeded in making them himself, hastened to publish the secret.

As to the more powerful optical instruments, the telescope and microscope, although it would appear that Alhazen* in the 10th or 11th century, Roger Bacon in the 13th, and Fracastoro and G. B. Porta in the 16th, had some idea that lenses might be made or combined so as to enable one to see distant objects better, or to magnify near ones beyond the power of normal vision; yet it must be held, with Kepler, that no instrument analogous to our telescope was known before the beginning of the 17th century, and that the possibility of the invention is limited to a very few men of that period. And, further, it is certain that the invention of the microscope was not anterior to the last few years of the 16th century.

Before proceeding with my subject in approximately chronological order, I must not omit to refer to the so-called Assyrian "lens," which is in the British Museum, and which was brought somewhat into fame some years ago by the publication of Sir David Brewster's opinion that he regarded it as a "lens," and as furnishing a practical demonstration that magnifiers were known to the ancients. I must also note upon two "bosses" of glass, recently acquired by the British Museum, which will doubtless be considered by some of the supporters of the antiquity of lenses as directly aiding to substantiate their views.

The Assyrian "Lens."—A piece of rock-crystal, of "plano-convex" form was found by Mr. Layard at the excavations of Sargon's palace, Nimroud, which had evidently been shaped oval by a process of chipping and grinding, and of which both the "plane" and "convex" surfaces had been ground and partly polished. This specimen is now in the Assyrian department of the British Museum, and in Sir David Brewster's opinion it is a "lens" designed for magnifying (*vide* Layard's "Nineveh and Babylon," pp. 197-8); it is shown in Figs. 1 and 2. As it was found together with certain objects of glass, one of which bears the name of "Sargon," I understand from Mr. Budge, of the Museum, that it has been possible to fix the date with reasonable probability to be not more recent than 721-705 B.C.

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* Cited in R. Smith's "Optics" (Cambridge, 1738, 2 vols. 4to.), ii., pp. 12-3., and thus translated :—"I find myself so pressed by age, that I can neither read or write without those glasses they call spectacles, lately invented, to the great advantage of poor old men when their sight grows weak."

* R. Smith's "Optics," ii., p. 15; Wilde, "Gesch. d. Optik," i., p. 70.

FIG. 1.

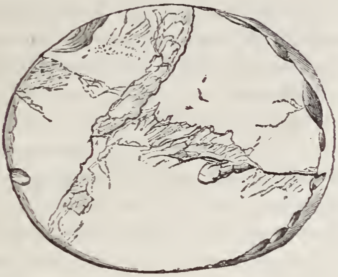

FIG. 2

ASSYRIAN "LENS" (721-705 B.C.)

After repeated examinations of this piece of rock-crystal, I am unable to agree with Brewster's opinion. I do not suggest the possibility of proving that it is not a lens; but I think no proof whatever has been adduced that it was designed as a lens, *i.e.*, to serve as a magnifier, while the probabilities seem against that supposition.

(1.) I would point to the fact, apparently overlooked by Brewster in his description, that the broad bands of cloudy striæ, extending diagonally and transversely through the substance of the quartz would form a serious drawback to its use as a lens, whereas they would probably be considered as adding to the beauty as an object of decoration. These bands of striæ appear too opaque in Fig. 1, though their general character, as seen under certain effects of light, is faithfully rendered. (2.) The term "convex," as applied to a magnifying lens, is generally understood to mean a smooth spherical figure, such as is produced by grinding in a spherically concave tool. But the "convex" surface in question was admittedly produced by grinding a multitude of irregular facets so as to approximate more or less to a shallow spherical or ovoid surface, much inferior to the surfaces the lapidary of the present day produces in tablets of obsidian, agate, &c., for brooches, bracelets, &c., of the commonest type. A surface of this kind is assuredly not "lenticular," as we apply that term to lenses. The Assyrian polishing was clearly of the roughest character, performed with apparent violence, and without regard to the existence of the deep scratches due to the grinding. The curvature is so irregular, and the polishing of both surfaces so imperfect, that objects appear indistinct even when placed in contact with the plane surface, while, if held some three or four inches away, the indistinctness and distortion render vision through the "lens" almost painful. (3.) Brewster says its "focus" is about 4½ in. from the plane surface. When held suitably to the sun, it is true there is a condensation of light which appears brightest at about 4½ in. from the plane surface; but this blurred mass of light can scarcely be termed a "focus" in the sense in which we apply that term to a lens.

Ancient Glass Bosses.—More recently the British Museum has acquired two antique glass bosses, the external form of which is so regular that if any contemporaneous work could reasonably be regarded as impossible of production without the employment of magnifying lenses, then these bosses might readily be supposed to be such lenses, either completed or in process of manufacture. But until collateral proof is found of the employment of magnifying lenses, any conjectures implying that these specimens were really designed as lenses must be mere guesses. The one specimen is of nearly hemispherical form, about 2½ in. diameter. The surfaces meet nearly in a sharp edge, and spiral and irregular scratches on both sides would suggest some grinding process of manufacture. The curved surface, when viewed by reflected light, appears so regular, that if it was not wholly produced by grinding in a concave tool, or by some equivalent process, it was probably cast in a very smooth and regular mould, and then ground and partially polished. Unfortunately, both surfaces are decomposed and almost wholly covered by a semi-opaque opalescent shell; and where fragments of this shell have broken away, so that the body of the glass is exposed, the surface of the latter is covered with minute pits, and is generally disintegrated so that one cannot see through the substance. The second specimen seems to have been originally about the same size and shape as the former, but is now a broken segment somewhat less than half its original size. The surfaces are much less injured by decomposition than in the former one, but still they are so dull that one cannot see an object distinctly through the substance. The surfaces of fracture show that the glass is clear and transparent, and of slightly straw-colour. When viewed by reflected light the curved surface does not appear so regular in figure as the former one, and may possibly have been moulded by heat without further process. The date assigned to these "bosses" by the Museum authorities is not later than 270-260 B.C.

And now, assuming that we cannot affirm with reasonable certainty that magnifying lenses were employed before the invention of spectacles, we shall not, I think, be far wrong in supposing that the gradual deepening of curves would lead to the production of lenses of shorter and still shorter focus, until a point was reached, when the combination of a convex lens as an object-lens with a concave as an eye-lens, accidentally distanced apart by the hands, would lead to the discovery of the telescope and microscope of the form generally associated with the name of Galileo, but which, from the testimony of Galileo himself, was of Dutch origin,* and of date anterior to his own production of the telescope in 1609. This would appear to be the probable origin of the microscope consisting of a combination of a convex object-lens with a concave eye-lens.

The Keplerian microscope, consisting of a combination of a convex object-lens with a convex eye-lens—which is the simplest form of what is now termed a "compound" microscope—was probably later in date, subsequent even to the publication of Scheiner's "Rosa Ursina," in 1630, in which the actual construction of a Keplerian telescope was claimed by Scheiner, and notified as dating thirteen years previously, when he showed it in action to the Archduke Maximilian.

The optical system was clearly laid down by Kepler, in his "Dioptrice," in 1611. I remark, however, that Descartes, in his "Dioptrique," published with his "Discours de la méthode" (Leyden, 1637, 4to), describes and figures both a microscope and a telescope with concave eye-lenses, and says not a word of the Keplerian forms of these instruments; the inference is, that he knew only the "Galilean" constructions* and the simple magnifying lens at that date. Moreover, the first publication of a Keplerian microscope actually constructed was by Fontana,† in 1646. Manzini, in his work "L'occhiale all' occhio" (Bologna, 1660, 4to.), pp. 174-5, refers to one of these microscopes made by Eustachio Divini, in 1648, which he states could be reversed, noting this reversal as a peculiarity of the construction, but not recommending it in practice; and he speaks of it as made on the Keplerian optical system as devised by Fontana. It would thus appear that we must not assign the origin of the Keplerian microscope, as an actual construction, to an earlier date than 1646. It is true Fontana claims to have devised the instrument in 1618, but that date is wholly repudiated by Montucla and by Poggendorff.

MODERN MICROSCOPES TO THE DATE OF THE APPLICATION OF ACHROMATISM.

It is, perhaps, impossible to assign the exact date of the first production of the microscope (as distinguished from the simple magnifying lens); but those who have given special attention to the early testimony on the subject—notably, Van Swinden, Moll, Harting, and Poggendorff—are agreed that it must have been between 1590 and 1609; and that either of three spectacle-makers of Middelburg, Holland, named Hans Janssen, his son Zacharias Janssen, and Hans Lippershey, may have been the inventor, the probabilities being slightly in favour of the Janssens. Poggendorff considers the official documents found by Van Swinden in the national Archives of Holland, extracts from which were published by Moll in 1831, prove conclusively that Lippershey invented the binocular telescope (with concave eye-lens—the "Galilean" form) in 1608, the lenses of which were constructed of rock-crystal in consequence of the extreme difficulty in obtaining clear glass in Holland. By the testimony of Pierre Borel,‡ and from personal information supplied to him by Willhem Boreel, Dutch Ambassador in Italy, who was a native of Middelburg, and had known the Janssens, father and son; he had often heard from the elder Janssen that he and his son were the inventors of the microscope, and that he had sent one to Prince Maurice of Orange, and another, later on, to the Archduke Albert of Austria. Boreel further stated that when he was Ambassador to England, in 1619, he saw the latter instrument in the hands of his friend Cornelius Drebbel, and described it as having a tube,* eighteen inches in length and two inches diameter, of gilt brass (copper), supported by three dolphins on a base of ebony; and that objects placed on this base were seen considerably magnified through the tube. In 1610 (according to Boreel's recollection), the Janssens succeeded in producing a telescope for celestial observations.

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* An able discussion of the evidence regarding the invention of the telescope is contained in Chap. xx. of R. Grant's "Hist. of Physical Astronomy," London (1852), 8vo.

* Referring to telescopes of this form, which he states were invented about thirty years previously (*i.e.*, about 1607) by Jaques Metius, of Alcmar, Holland, Descartes says:—"Et c'est seulement sur ce patron, que toutes les autres qu'on a veües depuis, ont esté faites...." (And it is on this pattern only that all others seen hitherto have been made). "La Dioptrique," p. 2. Descartes had evidently not met with the Keplerian telescope in 1637.

† "Novæ cœlest. terrest. rerum observ.," Neapoli (1646), 4to.

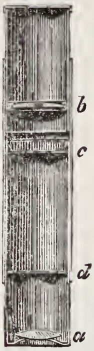
‡ "De vero Telescopii inventore," Hag. Comit. (1655), 4to. (contains portraits of "Zacharias Iansen" [Janssen ?], and "Hans Lipperhey" [Lippershey ?]).

It is upon this evidence generally, supplemented by that of Hans Janssen, the son of Zacharias, given in 1665 (1655 ?) regarding his father's statements anent his early connection with the invention of telescopes and microscopes, that the possibility of the invention of the latter is pushed back even as far as 1590. And it would appear that the first microscope on record was designed principally to view objects by reflected light, not by transmitted light.

"Janssen's" Compound Microscope.—Some years ago (1866) an old microscope was found at Middelburg, which Professor Harting thought might possibly have been made by the Janssens. It was exhibited at the Loan Collection, in London, 1876, and is shown in Fig. 3. I have here a copy of the original. It is of the Keplerian form, *i.e.*, consists of a combination of a convex object-lens and a convex eye-lens, which form was not published (as an actual construction) till 1646, by Fontana; hence, I think Harting was mistaken in assigning the construction to either of the Janssens. Nevertheless, because Harting thinks it may date back so early, I give it the first place in my budget of illustrations of modern microscopes.

This instrument is strictly a compound microscope in the modern sense, though without a field-lens, and this latter fact enables me to admit that it may, at any rate, have been constructed before the application of the field-lens to the microscope by Hooke, in 1665 (*vide* Preface to Hooke's "Micrographia"). The distance between the lenses can be regulated by two draw-tubes (one of which carries the object-lens in an inner adjustable tube) of thin iron-plate, fitting at either end of a middle-tube serving as a socket, so that within certain limits the magnifying power may be varied. There are three diaphragms in the instrument, one is placed at a variable distance in front of the object-lens, a second is at a fixed distance behind that lens, and the third is at a fixed distance above the eye-lens. This disposition of diaphragms is of great interest, especially if Harting is right in assigning the construction to the beginning of the 17th century. The eye-lens, *b*, is held in a simple wood cell by means of a wire ring sprung in; the object-lens, *a*, fits against a narrow metal flange at *d*, where it is held by a sprung ring. In the original instrument the latter ring is absent, so that the lens is loose, as shown in the Fig. (at least that appears to me the probable explanation of the fact that the lens is not fixed in its cell).

FIG. 3.



"JANSSEN'S" COMPOUND MICROSCOPE.

The "Microscopium Pulicare." — Before passing to the microscopes of which the dates can be fixed with greater certainty, I must call your attention to a form of simple instrument termed by the earliest modern writers on optics the "Microscopium pulicare," "Microscope de puce," or "Flea Microscope." It is shown in Fig. 4 (p. 994), copied from Zahn's "Oculus Artificialis," 2nd ed. (1702), p. 342. The references contained in the first edition of this work (1685), and in earlier works by Kircher, Schott, Descartes, and others, clearly indicate that such instruments were known early in the 17th century.

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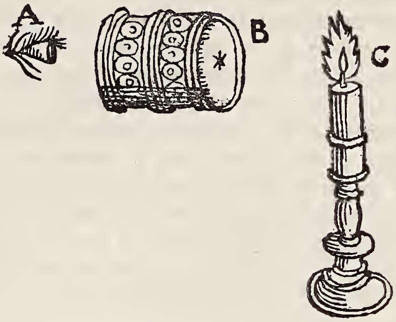
* I here follow Poggendorff, *loc cit.*, p. 111.

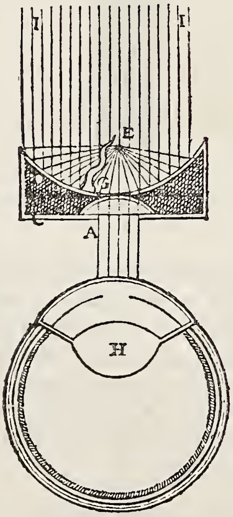
Fig. 4.



Microscopium Pulicare.

Descartes' Microscopes.—We now arrive at the earliest published figure I have met with of a simple microscope. It was given by Descartes in his "Dioptrique," in 1637, p. 126, and is shown in Fig. 5.

Fig. 5.



Descartes' Simple Microscope with Reflector (1637).

Descartes claimed that it was much superior to the (then) common form of Flea Microscope. You will observe that the arrangement is practically identical with the simple lens mounted in a central aperture in a polished concave metal reflector, generally known as "Lieberkühn's" lens, constructed by Lieberkühn, about 1738. Lieberkühn's device followed the publication of Descartes' figure about a century. Descartes suggested the application of a short spike (seen at G in the Fig.) to hold the object at the focus of the plano-convex (hyperbolic) lens, which was to be directed fully to sunlight.

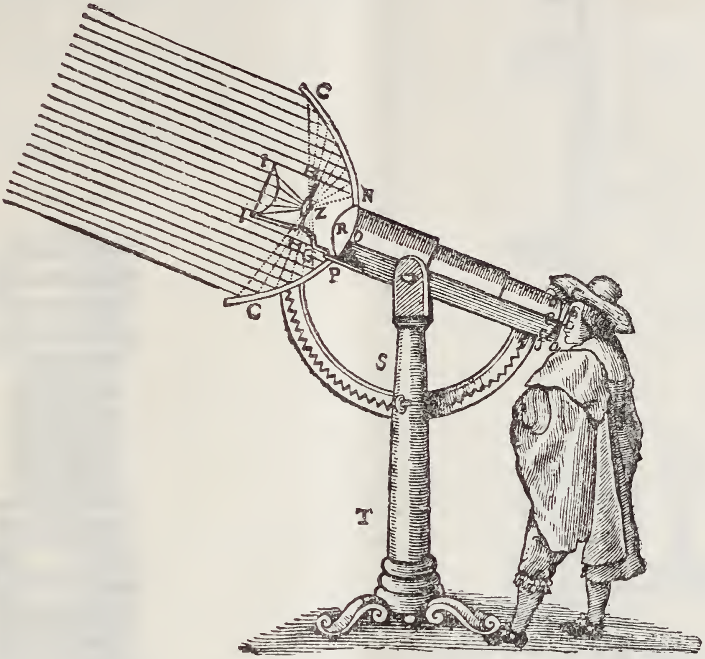
In the same publication (p. 132) Descartes also figured a microscope of colossal size, consisting of a combination of a bi-convex object-lens and a plano-concave eye-lens (both supposed to be worked to hyperbolic curves), and with an enormous perforated parabolic concave mirror encircling the object-lens to illuminate opaque objects, and a condensing lens in the axis of the instrument for illuminating transparent objects. This microscope is shown in Fig. 6 (p. 995). We have here the first combination, I have met with figured, of lenses forming a microscope. No means are provided for focussing except (apparently) the movement of the draw-tube containing the eye-lens. The dimensions and general form seem to me so very impracticable, especially for that early date, that I question if the device ever proceeded beyond the publication of the figure, while Descartes' instructions, that both instruments should be used with full sunlight, would also imply that he had never really used them in this way. I can hardly suggest what kind of object would not be vaporised in a few seconds if exposed at the focus of the gigantic parabolic mirror of the second form of Descartes' microscopes.

Descartes' microscopes were briefly referred to by Kircher ("De lum.et umb.," lib. 10), and by Gaspar Schott ("Magia Universalis," 1657-9, I., p. 535), but have generally been passed over by later writers, including Harting; the larger one has probably been frequently mistaken for a telescope. In the above-cited work, Descartes was, I believe, the first to publish figures and descriptions of machines for grinding and polishing lenses, thus preceding Manzini by twenty-three years, and Hooke by twenty-eight years.

"Divini's" andot her Microscopes.—In the above-cited work of Gaspar Schott five forms of microscopes are given (Pl. xxv., p. 525), which are here shown in Figs. 7, 8, 9 (p. 995), 10 and 11 (p. 996). Fig. 8 may have been of the Keplerian form; but this is not certain. Schott states (p. 535) that Fig. 10 represents a microscope constructed by Eustachio Divini; but I have much difficulty in supposing that it can possibly have been intended for any serious purpose. Divini was a distinguished optician of his time, one of the very few in Europe then

capable of producing telescopes for astronomical observations. He was the rival of Giuseppe Campani, Torricelli, and Huyghens, and was referred to in terms of great respect by Manzini (in the work above-cited, where Divini's portrait is given), and by Fabri (" Synopsis optica," Ludg., 1667, 4to), so that I think it improbable that he ever seriously devised a microscope without arrangements for illuminating the object to be examined, and of such unwieldy dimensions that the observer had to place himself as shown in the Fig. to look down the tube.

FIG. 6.



DESCARTES' "GALILEAN" MICROSCOPE (1637).

I have already mentioned that Manzini had

FIG. 7

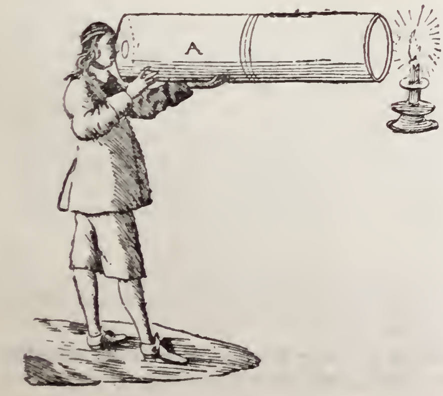


FIG. 8.

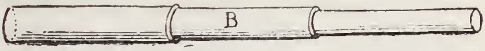


FIG. 9.

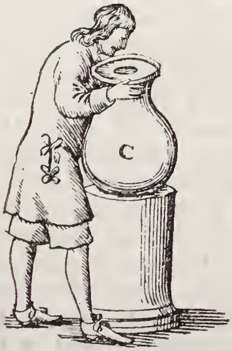
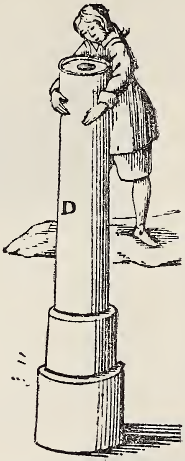
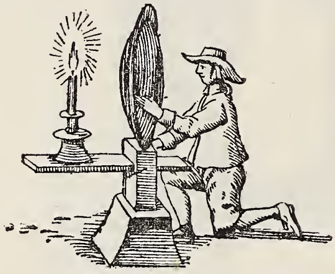


Fig. 10.



"Divini's" Microscope (1657).

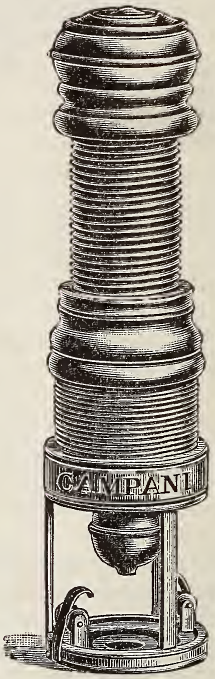
Fig. 11.



seen a Keplerian microscope made by Divini in 1648; we shall presently come to one of his instruments made in 1666-7, showing that he realised the meaning of a microscope of convenient dimensions, and that he aimed at improvement in the optical construction—improvement that was immediately appreciated by Christopher Cock, the optician, of London, who appears to have worked out Hooke's ideas, and which led Grindl to the improved optical construction published in his "Micrographia nova," in 1687.

Campani's Compound Microscope.—The next microscope of special interest is one by Giuseppe Campani, shown in Fig. 12 (about two-thirds linear size). There is no field-lens in this instrument, and as Campani was an optician of considerable note, he would hardly neglect so important an innovation after its publication; we may, therefore, I think, safely assume the date of the construction prior to that of Hooke's microscope of 1665, in which the field-lens was claimed as a novelty. Campani provided a double focussing arrangement, one for regulating the distance between the object-lens and the object, the other for varying the distance of the eye-lens from the object-lens. The application of the second plate, held by springs to the base, for clipping the object-slide while permitting a fair range of movement, is good, and may have suggested the spiral-spring arrangement devised later by Bonanni. The central hole through both plates was clearly intended by Campani to enable the observer to examine transparent objects by holding the microscope to the sky or other source of light. The screw-focussing, by which the wooden optical tubes were rotated in a loosely-fitted metal screw-socket, must have been unsteady in practice; it is, however, the first system known to me of screw-focussing applied to a microscope.

Fig. 12.



Campani's Compound Microscope (*ante* 1665 ?).

For the use of the woodcuts, Figs. 1, 2, and 3, my acknowledgments are due to the Royal Microscopical Society.

Figs. 4, 5, 6, 7, 8, 9, and 10, were reproduced from the original Figs., in the works cited.

Fig. 11 was photographed on the wood-block from a photograph of one of the original instruments, to ensure the accuracy of the drawing.

For the loan of the large collection of microscopes exhibited in illustration of various points touched upon in this and the succeeding lectures, my acknowledgments are due to the Royal Microscopical Society, Mr. Frank Crisp (Secretary of that Society), and M. Alfred Nachet, of Paris.

ELEMENTARY LECTURES.

ELECTRICITY.

BY PROFESSOR GEORGE FORBES.

Lecture II.—Delivered April 10, 1886.

"CURRENTS AND RESISTANCE."

In the course of my last lecture I showed you the generation of an electrified condition of space, and the electric forces which were thereby produced, and I explained to you what we meant by saying that two things have a difference of electric potential. I also explained to you the condition which exists when two bodies have a different potential, that is to say, that there is then created electromotive force, and if this electromotive force be free to act through a conductor so that induction takes place, there is a momentary current, and rearrangement of the electrification. If, however, the electromotive force is acting on an insulator no current can pass, and there is simply a strain created in the insulating medium which is ready to produce the phenomena of induction as soon as a facility is offered by the presence of a conductor of electricity. We are accustomed to measure our difference of potential in terms of some unit, and the unit which has generally been adopted is called a volt. When I say there is a difference of potential between the two knobs of the machine I am using, amounting to 50,000 units, I mean 50,000 volts, and that is about the difference of potential which we are in the habit of employing when we are using the electric machines. Wnen I rub a piece of sealing-wax on flannel I get a difference of potential amounting to an enormous figure like that, and yet I can get no serious injury from it, because the quantity of electricity is so small. We shall be coming on to-day to learn the means which we have for generating electricity in much larger quantities than we can even by means of the Wimshurst machine; but when we come to experiment with batteries, or the other means for generating electricity in quantity, we shall be using very much smaller differences of potential than what we were using in the last lecture. A single cell of a battery may have one or two volts difference of potential, but that difference of potential which exists in a battery is exactly of the same nature as that which exists in the Wimshurst electric machine which you saw last time. The electric current which passes to the earth during a lightning flash is identically of the same character as that electric current which passes through each telegraphic instrument from our batteries, or which is lighting up this room at present by means of these glow lamps. It is hardly necessary, at the present time, to insist on this—that there is only one kind of electric current. In former days it required the researches of the ablest experimenters to prove to the world that the electric current which might be generated by means of apparatus like our Wimshurst machine, was the same in character as the electric current which can be generated by means of plates of metal in acidulated water. But we know with certainty that the effects are the same. I shall simply show you one experiment with the Wimshurst machine, to prove to you that one of the facts which we frequently find in dealing with batteries, can also be produced by means of such an influence machine. I have here a small strip of tinfoil which I shall place between two pieces of glass, and I shall then subject the two ends of the tinfoil to an electromotive force due to the difference of potential between the two knobs of the machine. Then when I discharge this machine by means of the assistance of the Leyden jars which are attached to it, we shall be able to pass an electric current through this piece of tinfoil, and show the heating effect which is thereby produced. This will be an apt illustration of the analogous effects which can be produced by means of this influence machine, and the totally different means of generating electricity which we have in batteries and dynamo - machines. On turning the handle now the spark has passed between the poles, and I will hand round as a specimen one of the pieces of tinfoil which was put their originally, and show you the fused condition of the tinfoil after the spark passed through it. Here is another specimen in which the effect is even more powerfully shown, because not only has the tinfoil been actually fused, but the glass has been shattered by the power of the discharge.

The quantity of electricity which is developed in the course of these powerful discharges is very small indeed. In fact, Faraday stated that in the most powerful lightning flash there is not so much electricity passing as there is at the time when we decompose by the electric current a single drop of water. There are many ways in which we can conceive of an electric current passing while electrified bodies are being discharged; for instance, if a conductor were moved backwards and forwards between these poles there would be a regular passage of positive electricity from one knob to the other, and of negative electricity in the opposite direction, which transference of the electrical condition is identical in character with an electric current. Many years ago, Professor Rowland, of Baltimore, then working in Professor Helmoltz' laboratory, in Berlin, showed that an electric current could be produced in another way. Simply by charging a body with electricity and moving it with great rapidity, he was able to produce effects analogous to those which are seen by the use of the current generated from the battery—such effects as we shall presently be observing. Thus Professor Rowland actually proved by experiment that the carrying of a charged body through space is equivalent in its action to an electric current such as we shall be dealing with to-day. [I believe that this experiment has never been successfully repeated.]

I will now show you some of the simpler methods which we have for creating an electric current, and I will begin by throwing on the screen an image of a cell containing dilute sulphuric acid. I will introduce, in the first place, into the cell a wire of copper. You see that the wire is in perfect focus, but nothing else is seen—there is no formation of gas or anything. I will now introduce a piece of zinc, and there is no formation of gas appearing there. I will now introduce the two simultaneously, the zinc and the copper, and still there is no appearance of any gas whatever. But as soon as I touch the two metals at any point outside or inside the liquid you see that there is an evolution of gas. The gas now is seen to be coming off from the thin wire which is of copper; that gas is hydrogen gas, and it shows that the condition of the cell is something different from what it was before. As a matter of fact, there is an electric current passing through these metals and through the liquid. Instead of connecting them in the liquid it is sufficient to connect them outside the liquid, and still you see the gas is coming off from the copper—the hydrogen is seen rising in small bubbles. Now, instead of connecting them as I have done at present just outside the cell, I will connect them metallically by a long wire which passes to this apparatus here, and round the coil which you see facing you in the instrument on the table. Inside the coil is a magnet, to which the vertical index is attached. We shall see that when the current which I have spoken of is circulating through the wire of this coil, there is a deflection of the magnet, and that will serve as an indicator to us in the rest of our experiments to show when we have got a current or not. I now replace the zinc and copper in the solution, and you see the bubbles being given off, and, at the same time, you can mark the deflection of the index, indicating on that apparatus in the centre that there is a current passing. I break the circuit by removing the zinc or copper, and the current will cease to flow, no more gas is evolved, and the index, after a few vibrations, returns to rest. In making a coil for this purpose it is necessary, in order that the current may circulate through all the different convolutions of the coil, to separate them from each other by an insulating material. If this were not done the current would take a short cut, and would not go along all the successive coils. For this purpose the wire of my coil here is covered with silk—silk being an insulator. That silk is not thick, but is sufficiently thick to prevent the difference of potential from sending electricity across from one convolution of the wire to another. If I were using a very high difference of potential it would be necessary to use something thicker than that thin coating of silk, and that is a point which has to be attended to in the construction of powerful dynamo machines and other apparatus, that the insulation shall be sufficiently strong to resist the difference of potential between the successive coils.

We shall be using this apparatus as a galvanometer, a means of measuring the current on several different occasions. But we have an apparatus which is very often used by investigators, and which to the philosopher is peculiarly suitable for some very delicate measurements. That instrument is the ordinary telephone, the Bell telephone, which consists of a magnet with a wire wound round its end attracting a flat disc, and if an interrupted current is passed through the wire it alternately attracts and ceases to attract that disc. The consequence is that the movement of the disc sets the air into vibration, and an audible sound is heard. As this instrument has become one of great use in scientific research in the course of the last few years—one which Prof. Hughes has most largely used in his ingenious researches—I think it worth while just to direct your attention to this delicate instrument for measuring currents, and in order to show you the way in which it acts, I will connect it with the battery, and rub one end of the wire along the terminal of the battery so as to make and break contact very rapidly. The telephone now gives out a noise which can be heard by every person in the room. That noise is coming from the telephone. You cannot hear the noise I am causing by making and breaking contact. A telephone is able, then, to make that current audible all through the room, and you may imagine what a very feeble current may be made audible when the experimenter himself places the telephone close to his ear.

This, then, proves to us some of the effects which are produced by an electric current. The electric current is simply the result of our having an arrangement which enables us to keep up a constant electromotive force. In the case of the influence machine which I have been using so frequently, I am not able to maintain that high difference of potential constantly if the two knobs are connected by a conductor, because as soon as the contact is made by the conductor, the whole of that small quantity of electricity which is accumulated on the knobs spreads through the conductor, and annuls the whole effect. It is only by having a copious quantity generator, or current maintained by the chemical action which is going on in this cell that we are able to get a constant flow of electricity through the wire. But a difference of potential is created in this cell, exactly of the same nature as the difference of potential which we have between the poles of that machine, and the result is the production of the current yielding to the influence of the force thereby created.

Now I would like to bring to your minds a little more clearly the bearing of what I have spoken of as the electromotive force of the cell. I have been using in this cell a piece of copper and a piece of zinc in dilute sulphuric acid, and the electromotive force of the arrrangement is perfectly definite. It is about one volt. It does not depend in any manner on the size of the apparatus. I have here a cell containing large sheets of copper and zinc, and the electromotive force which is created in this cell is not one particle greater than the electromotive force which is created in this very small cell. I can show this to you in a very convincing manner. I can connect this little cell here with the very large cell there in two different ways. I may connect the zinc of the one with the copper of the other, in which case I get a double effect; I get the sum of these two electromotive forces working throughout the metallic circuit; or I may connect the zinc of this cell by wire with the zinc of the large cell, so that the two electromotive forces are acting in contrary directions. We shall then be able to see whether the electromotive force of the one is equal to the other, because the galvanometer will indicate to us the effect produced, which is due to the difference of electromotive force, whatever it may be between the two cells with which we are experimenting. I have now all the connections perfectly correct, so that the zinc of the little cell is connected directly with the zinc of the large cell; the copper has a wire passing through the galvanometer back to the copper in this large cell. The electromotive force of the large and small cell are acting in opposite directions on the circuit, and now we shall see which is strongest. If you watch the galvanometer while I introduce the zinc into the small cell, and so complete the circuit, the deflection will be a very small one indeed. It is now introduced, and there is really no deflection at all. The pointer is actually at zero, showing that, although I have two batteries in circuit, each capable of giving the deflection which you saw before, when they are opposed they are exactly equal in their effect; and this small cell with its little piece of zinc and copper is able to counterbalance this large cell with its large sheets of copper and zinc. This effect has its analogy in what used to be called the hydrostatic paradox, viz., that a weight, however large, may be balanced by any weight, however small, by hydrostatic pressure of liquid in two cylinders having pistons of suitable areas.

It will be well now to say something about the different kinds of batteries which are used. This arrangement does very well for a short time, but the trouble is the gas which you saw on the screen being deposited on the copper; that hydrogen gas has an enormous influence, and tries always to set up a current in the opposite direction to the current which we wish to utilise. Various means have been proposed to get rid of this hydrogen. The first arrangement which was completely satisfactory was what was known as the constant cell of Daniel. Here I have a double cell of Daniel's construction, and here I have a slightly different cell, which you can examine afterwards, also of Daniel's. Daniel's cell consists of plates of copper and zinc. The copper does not dip into the same vessel as the zinc, but is put into an interior vessel of porous material through which the liquid can soak, and this porous vessel is filled with a solution of sulphate of copper. The outer vessel, in which the zinc is, contains dilute sulphuric acid. In this case, hydrogen is generated exactly as it was in the experiment on the screen, but with this difference, that the hydrogen never reaches the copper, because a solution of sulphate of copper has this action, that it gives up the copper from its molecules, and takes in the hydrogen instead, and thus the solution of sulphate of copper is decomposed, and part of it is converted into sulphuric acid, because when we substitute hydrogen for copper in sulphate of copper it is turned into sulphuric acid. Those bubbles of hydrogen are never allowed to accumulate on the copper plate, but copper is deposited there instead, and the result is we have constancy of action, and not that polarisation, as it has been called, which is so injurious to the action of many batteries. In the centre of the table there is a large battery of Daniel's cells where you see the arrangement when they are put in series, *i.e.* the zinc of one connected metallically to the copper of another, so as to increase the electromotive force. There are five of those cells in the battery, and, therefore, we have five times the electromotive force, five times the power of overcoming resistance which we had before. Here are also various types of Leclanché's cells which are used by the Post-office in much of their telegraphic work. Here I have a battery of a totally different construction. This is not dependent on chemical action, but is dependent on the conversion of heat more directly into electricity. This pile which you see before you consists of a series of elements, each made of two different metals; one is of iron, and the other is a compound of zinc and antimony. Each pair is joined together at the outside of this pile, and they are then joined so as to make a continuous series, making in all something like 75 pairs, coupled together in series so as to multiply the electromotive force of a single pair by 75. This is connected with the galvonometer. When I make contact there is no current passing whatever, the reason being that the temperature of the inside junctions and the outside junctions of this apparatus are the same. Now, I will heat up the interior by means of a Bunsen burner, and you will gradually see the formation of a current. It takes some five or ten minutes to acquire its maximum effect, but even already you notice by the galvanometer the current which is being sent through, although the rise of temperature at this stage is very slight indeed, but it soon becomes amply sufficient to show the production of a considerable thermo-electric current.

In a battery we have two things to consider, not only the electromotive force it is capable of generating, but also the resistance of a battery. When we have our complete circuit, consisting of any one of these batteries to generate electricity, wires going to the apparatus to carry the electricity, and a piece of apparatus in which the electricity is to be used, we have two things to consider. We have a certain amount of electromotive force in this circuit, and we have a certain amount of resistance in this circuit, and the greater the electromotive force, the greater will be the current we get, and the less resistance in the circuit, the greater will be the current which we get. Consequently, in order to get the best effect, we generally have a battery of very low resistance, and very high electromotive force. But we also wish to have a small resistance in our wires which go to the apparatus where we are using the electricity, and we also want a low resistances in the apparatus where the electricity is being used. The resistance of my battery depends on the amount of surface of metal exposed. At the present moment I have the zinc plate fully immersed, and the copper plate only just dipping in the liquid, and you see we have a deflection on the galvanometer of about 45°, or thereabouts. Now I can vary the conditions of the problem by varying the resistance of the battery, leaving the resistance of this galvanometer the same; leaving the wires identical, I can lower the copper plate into the liquid, and so diminish the resistance of the battery, and as I do so the deflection immediately increases, and now the needle is permanently deflected quite to the end of the scale, and it resists any effort to cause it to rise, showing then that the current is stronger when the resistance of the battery is diminished. In the same way, if I bring the plates nearer together the resistance is less, and consequently we get a greater deflection. Either having a larger surface of plate, or having the plates nearer together tends to diminish the resistance. Now what happens during the time that our current is passing? I am not going to ask you to go into theoretical views, or any person's notion of electricity in this matter. We know that there is a certain stress in the medium when electrified bodies are fixed and in equilibrium, and we know that there is a change in the condition of stress when the equilibrium is destroyed; but I am not at present intending to go into the question of what kind of change that is, and what is the condition of the medium, under those circumstances. I wish to ask what becomes of this energy which is being created, when it is overcoming resistance, in the outer circuit? The answer to that is, in the first place, that the energy cannot be destroyed, and in accordance with the principle of the conservation of energy we must be able to find out what it is converted into. We find, by experiment, that the energy of electricity when passing through a resistance is converted into heat. This is a transformation of one kind of energy into another, a transformation tending to uphold the principles of the co-relation of the physical forces, and the conservation of energy, of which there are so many illustrations in the study of electrical science. It is but a few moments ago that I was showing you the transformation of one kind of energy, heat, into the other kind of energy, electricity, and now we are speaking of the return of changing the electrical energy into the energy of heat. I might show you many illustrations of this principle, but I could not show you a better one than the means of illumination, which we have in this room at the present moment. In everyone of those glow-lamps we have a brilliant illustration of the conversion of electricity into heat. The resistance of those glow-lamps is very large indeed, and nearly the whole of the electric energy which is consumed in those lamps is shown to us by the brilliant light, and consequent radiation of heat also which takes place in those glow-lamps. I will, however, make use of those very glow-lamps to illustrate some of the other points in connection with resistance. I will connect one of these lamps with a source of current, that is to say, with a battery containing a certain number of cells. Fifty-five cells, each of two volts electromotive force are upstairs connected with the wires I hold in my hand. I now make the contact here, and immediately, the glow-lamp which is in circuit gives off a certain amount of heat, and that brilliant incandescence is an indication to you of the resistance of the circuit when a single glow-lamp is in the circuit. I now change the connection and put two of these glow-lamps in series, so that I have nearly doubled the resistance of the circuit. You will see that the current is by no means so strong, as is shown by the fact that the lamp only shows a dull red heat. I might show you numerous illustrations to confirm your appreciation of the fact that when we increase the resistance we diminish the current, and when we diminish the resistance we increase the current. I will take one more example here. Here I have a platinum wire stretched, through which I will pass an electric current so as to render it incandescent. Part of this platinum wire is straight, and a small part of it is coiled up into a spiral; I will place a spirit lamp under the coiled part, and by heating this with the lamp I increase the resistance of that portion, because the resistance of a metal increases with temperature. What I want you to see is that when I increase the resistance of the platinum wire by bringing the spirit lamp under it, the current is diminished, as shown by the intensity of the glow in the other part of the wire. Now you see the effect. I will now show you the converse experiment. I shall cool the coil, thereby diminishing the resistance, and increase the current that flows through the wire, and this will be perceptible by an increased glow in the straight portion. I now bring a piece of ice in contact with the coil, and you see there is a distinct increase in the brilliance of the straight part of the wire. I will now again try the effect of heating it still more by the aid of the spirit lamp. There is a decided diminution of brightness in the straight portion of the wire, showing that the current has been diminished owing to the increase of resistance in the heating of the coil.

I have shown you now how the current may be increased or diminished by the resistance which is in the battery or which is in the conducting wire, but I should like to show you a similar effect with the galvanometer, and this leads me to say a few words about the choice of a galvanometer for delicate experiments. The greater the number of turns I have round my galvanometer the more is the needle influenced by the coils of the galvanometer; each turn exerts its influence, and, therefore, you may expect the larger the number of turns you have round the galvanometer the greater is the influence on the needle. But, on the other hand, when we increase the number of turns round the galvanometer, we increase the resistance, and owing to that, when we increase the resistance too much, we may diminish the effect on the galvanometer. It has often been remarked for certain kinds of work, such as electric telegraphy, we require a high resistance galvanometer, and the student is sometimes perplexed and led to think that the virtue of the high resistance galvanometer is in its high resistance. It would, perhaps, be less misleading to call it a many coil galvanometer, because it is the multiplication of coils which is useful—the resistance is altogether injurious. I have here a compass needle which I am about to project on the screen with the oxyhydrogen light, and I will try to show you the effect of coils through which a current is passing on the compass needle. Now I have a coil introduced which is capable of deflecting it. I will connect the coils with a battery, and you observe the deflection. I wish you to observe exactly the position of the needle—it is the fourth division from the zero line. At the present moment I have 10,000 turns round the coil of my galvanometer. I will reduce the number of turns by 2,000, and you see that the deflection actually increases; you would have thought that a decrease in the number of turns would have decreased the deflection, but in decreasing the number of turns I have also decreased the resistance, and the result was that the compass used went further away from the zero line. I will now take out another 2,000 turns, and there is another slight increase showing increase of effect. Finally, I will take out another 1,000 turns, and there will be a slight impetus, I think, still in the same direction, thus showing that sometimes we get an actual increase in the deflection when we diminish the number of turns in our galvanometer.

Another very beautiful illustration of the consumption of energy by producing resistance is in the electric arc. The electric lamp which you have seen at work in the different illustrations is produced by two pieces of carbon connected with the poles of a powerful battery and brought first to touch each other, and then separated to a slight distance. This experiment was first performed by Sir Humphry Davy. I will throw on the screen the image of two carbon rods, whose points are placed opposite each other, and a great deal can be learnt by a careful study of that magnified image. In the first place, I show you that they are not actually touching, and a current is passing across. The only reason why the current is passing across that sensible space of air is because the air has become intensely heated, and when the temperature of the air has increased so enormously as it has in this case, it becomes a very fair conductor of electricity. [A metal on the contrary becomes a worse conductor when heated.] I will now separate the carbon points. There they are, glowing hot from the high temperature to which they have been subjected. Now they approach until they touch, but no current passes between them until the carbons actually touch; then the air was sufficiently heated to allow them to be separated a little distance. You also notice the particles of carbon continually falling off—small portions of electrified matter which are continually being repelled from the carbon point. One pole is called the negative pole, being connected to the zinc, and the other is called the positive, which is connected to the copper of the battery; you will notice also an accumulation of impurities in little globules on the surface of the carbons. I should like, while we have this on the screen so clearly, to be able to show you the deflection of the current, which you can see by the luminous gas which exists between the two poles, so we will now introduce a magnet. You see the disturbance in the current due to the presence of the magnet, and a violent evolution of these particles of hot carbon at right angles to the natural course. The heated gas is altogether driven to one side by the close presence of the magnet to the arc lamp —the current is actually diverted by the presence of the magnet.

I want now to try and show you an experiment of another kind, not the heat which is generated by electricity, but the chemical action which can be produced. Here I have a current coming from two wires at the bottom of this dish of water, in which are two tubes also filled with water. The current passes from one wire to the other through the liquid, which is water. I shall be able to show you an evolution of gas immediately apparent. This is one of the most elementary of chemical phenomena which are produced by electricity. I will allow that to go on for a little time so as to get the tube filled with oxygen and hydrogen respectively, while I pass to another experiment illustrative of chemical action.

This is a very beautiful experiment. Here I have a steel plate highly polished—it has no markings on it whatever, it is perfectly plain polished. I put it into this vessel, which I shall fill with acetate of lead, over it I place a pattern which you see here cut out in cardboard, and over that I put a few bits of wood to support it, and on that a sheet of copper. Finally, I shall fill this vessel with acetate of lead, and pass the current through these, from the bottom steel plate to the upper copper plate. The consequence is, there will be a deposit of peroxide of lead on the polished steel plate, varying in thickness according to the influence which the current has had on the different parts of the steel plate, thereby showing the beautiful colours of thin plates, which Sir Isaac Newton worked at, which are caused by the varying thicknesses of the peroxide of lead on the steel plate. You see the colours which with the pattern are beautifully produced on the plate. It no longer retains that uniform polish it had before.

Now I return to the experiment of decomposing water, and will show you that I have really hydrogen and oxygen collected in these tubes; in the first place we shall know this is hydrogen by its being readily ignitable; on applying a light there is a little explosion, and the flame gradually travels down the tube as the hydrogen is being consumed. In order to show that the other one contains oxygen, I shall blow out a lighted taper, and then introduce it into the tube where the oxygen easily rekindles the smouldering wick.

Miscellaneous.

ECONOMIC PLANTS IN SOUTH AUSTRALIA.

The report of Dr. Schomburgk on the progress and condition of the Botanic Gardens and Government Plantations, Adelaide, South Australia, for the year 1885, has recently been published, and contains as usual many notes on useful plants of recent introduction into South Australia. Of the kumara (*Ipomœa chrysorrhiza*), a native of New Zealand, the plants are said to have grown well at first, and to have produced a fair crop of tubers, which were ultimately lost for want of sufficient knowledge of the method of treating them after they were taken from the ground. The season for planting the kumara in New Zealand commences at the beginning of October and continues till December. The ground is ploughed or dug with a spade, and formed into small hillocks, the soil being rendered fine by breaking up the clods. These hillocks are from 8 inches to 10 inches high and 2 feet apart. One tuber is planted in each hillock and barely covered with earth. The only after culture that is required is careful weeding. The time for taking them up is in March or April, the crops coming to maturity about the middle of March. The method of preserving the tubers which is in use is that of the Maori *rua*. This is a shallow pit dug in an easily drained place in any soil that will stand, the earth that is taken out being used to heighten the sides and to cover the tubers to make the roof. The sides of the *rua* are built without the use of water, the earth being simply rammed or beaten by hand. A post at each end forms a ridge pole, from which to the side walls bushes and pieces of wood are laid close together, and the whole well covered with earth. The tubers are also kept in shallow pits with a good layer of branches at the bottom, and a good covering of the same material at the top, before the earth is thrown on. If exposed much to the air they soon perish. The tubers are lifted with a sharp-pointed stick about a foot long, this is done very carefully so as to avoid bruising them, for those that are damaged decay very soon. If the tubers are left in the ground they speedily rot during the winter rains. The mode of cooking them, preferred by the Maories, is that of steaming them in their own ovens, though they frequently boil them new as they do potatoes. Some kinds of the kumara are rather watery. These are not suitable for boiling, as this process renders them more watery still. They are all much better when baked or roasted. Dr. Schomburgk expresses a belief that the kumara will grow well in the gullies, because the climate there is cooler and moister than on the plains, and to some extent approaching that of New Zealand. The plant has been recently introduced into the East Indies, where it has produced excellent crops. Mr. Duthie, of the Botanic Gardens, Saharunpore, says that he considers it a very valuable addition to the vegetables of India. The well-known oil seed, *Sesamum indicum*, which is so much grown in tropical countries has, after repeated trials, succeeded in Adelaide. The seeds were received from India, sown in the open ground in October, and came up in about fourteen days afterwards; from the success which attended their growth afterwards, there seems no doubt that this plant can be satisfactorily grown in South Australia. Two species of andropogon, or lemon grass, have been introduced to the garden during the last year, namely, *Andropogon calamus aromaticus*, and *Andropogon schœnanthus*, both of which furnish a nutritious fodder, and their fragrant roots yield an essential oil very much used in perfumery. Both of these grasses are said to thrive well in Adelaide, especially *A. schœnanthus*. Speaking of its success, Dr. Schomburgk says:—"If we are not able just at present to turn the odoriferous roots to good account, we may at least be satisfied that the colonial collection of grasses has been increased by two useful fodder plants which are able to survive the stress of our climate."

PRODUCTION OF PULQUE AND MESCAL IN MEXICO.

Pulque and Mescal, which are fermented and distilled liquors with a great variety of modifications, are made from the sap and root of the maguey plant or aloe, known as the *Agave Americana*. This plant, in some thirty varieties, grows wild throughout Mexico, and in many districts it is carefully cultivated. It enters into the domestic economy and habits of the Mexicans, and forms one of the most useful products of the republic. Its most important production is the fibre yielded by the long narrow serrated leaves with their prickly edges, when the same are pressed, and it is stated that this fibre is almost equal in quality to the best Yucatan heniquen, or jute. Ropes of great strength are made from some varieties of the plant growing in special localities, but the pressed leaves are everywhere of importance for the manufacture of paper. For many centuries past, textile fabrics have been made from it by the Indians. It is stated in a report of the United States Agricultural Department, that the Mexican Government is liberally encouraging the paper manufacture, and a large company has been organised to cultivate maguey plants on Government lands. The list of products furnished by the maguey is very large, and besides pulque, or Mexican beer, and mescal, the chief spirit of the country—a distillation resembling a coarse quality of gin, and very intoxicating in its character—there is a fine quality of brandy, known as *tequilla*. The daily consumption of pulque, or beer, in the city of Mexico alone appears to be about 150,000 quarts, and it appears to be the universal beverage of the country. Being in strength about equal to common cyder, it is of whitish hue, and has a slightly acid taste, with an odour which makes it very disagreeable to all but the natives. A maguey plant will reach its maturity in from five to ten years, and grows most rapidly in the warm sections, though not so luxuriantly in the hot coast belts. Large quantities of mescal are produced in the State of Oajac, and *tequila*, or magney brandy, comes chiefly from the district of the same name, in the State of Jalisco. *Tequila* is highly valued on account of its purity and strength. The Mexican Indians are said to be inordinately fond of pulque; it is consumed in large quantities, and forms the basis of a great number of liquors, all of which are intended to make it stronger or more agreeable. Pulque is made a source of large domestic revenue by all States; the daily tax paid on it at the gates of the city of Mexico is estimated at about £1,000. Another liquor produced direct from the maguey is known as hydromel, or honey juice, being the pure and unfermented juice or sap of the agave. *Pulque de chirmoya* is made from the hydromel of the cultivated agave, cut unripe at the age of three or four years. This is put into skins which have contained the "mother," or pulque made at the regular age, five years and upwards. When transported, the shaking gives it flavour and strength. A choicer liquor is made by heating, underground, old heads of agaves, grinding them coarsely on a stone, and then settling them to ferment in a pulque vessel, after which the contents are distilled. The first jar is known as *bingeré*, and the rest as *bingarroté*. *Pulque tlachique*, a favourite beverage, is made from tender agaves; cut when unripe. There are various admixtures made in connection with this. It is quite thick, and *quahchan* is the same, with the fruit of the Peru tree, deprived of its peel, and left in the liquid for three or four days. *Capololte* is made of the same variety of the pulque, with the seed of the red Peru tree infused therein. After fermentation it is hot and noxious. A species of mescal is made by distilling *pulque tlachique* and molasses, after being allowed to ferment in goatskin vessels. In addition to these, there are about seventeen other compounds made by mixing sugar and sweet almonds ground with the juice of cornstalks, sugar or honey being added; by mixing white pulque with blackberries, capulins, pepper, and sugar; by mixtures of prickly-pear juice and fermenting or distilling the same; by adding to white pulque, honey, pepper, anise and capsicum, leaving the same to ferment for twenty-four hours; by mixing pulque with wild plums (*jabos*) and sugar. *Mantequila* is made of pulque, brandy, and sugar. A wine named *rescado* is made of the trunks of agaves deprived of leaves, cooked in an oven for about a fortnight, then mashed and put with pulque into skins, to which is added mountain hysop, and the liquid is left for two days. *Tepemé* is a wine or liquor produced from the pressed leaves of the narrow agave, in which acacia wood is boiled in order to give it strength. *Mescalde guadalajara is* made by first fermenting in skins, water, honey, and agave heads, and then distilling the liquor. The maguey plant from which the pulque is made, grows as high as ten or fifteen feet, and the miel or juice is sucked up through a syphon made of a large gourd with a cow's horn in it, which is called *acajete*. Accompanying the men whose business it is to collect this juice, and who are called *thachiqueros*, are donkeys, which have their backs laden with sheep skins, into which the juice is poured after being sucked up by the syphons. The plant is prevented from flowering at the age when it usually yields pulque, and during its growth it throws out shoots or young plants which are removed from the parent plant when about three feet high, that is after two years growth. These are planted out at a distance of a yard apart. The *thachiqueros* go periodically among the plants, and mark those which are fit for tapping by cutting a cross on the top of the highest stalk of each plant. When the maguey is fit for tapping, the *thachiqueros* thrust aside the spiky stalks, and cut out the meyolote or central spoke, leaving a cavity which they visit after eight days, when it is full of juice. The plants only begin to yield juice when the flower stalk is on the point of its development, and this is generally discovered by the direction of the radical leaves. When the flower stalk is on the point of formation, these leaves rise from the earth to which they are inclined and endeavour to form a junction so as to protect the flower. They become also of a clearer green, and there are other signs which are closely watched by cultivators. The maguey, after the expiration of eight days, is tapped regularly three times a day, and yields over a gallon a day, and bears for three months, each plant producing about one hundred and twenty gallons before it dies. The juice, when extracted, is conveyed to a large building fitted with square wooden frames, on which are stretched cowhides shaped like vats, the hair being upwards. The liquid appears to curdle during fermentation, and has an offensive odour; fresh juice is applied three times a day, and when drawn off the liquor is placed in barrels and sold to the pulqueries, or drinking places. The city of Apam produces the finest pulque sent to the city of Mexico, and this sells readily at about fourpence a gallon. The maguey will flourish on the most arid and rocky soils, is not affected by drought, hail, or even severe frosts, and the plant is used for almost every domestic purpose, from making intoxicants to the thatching of huts.

PAPER MAKING IN SIAM.

Native paper is manufactured in Siam from the bark of a tree called *tou koi*, and the following is the process of manufacture. The smaller branches of the tree are cut and steeped in water for two or three days, the bark then is stripped off and brought in bundles and sold to persons who make the paper. The bundles of bark are put in water for two or three days by the paper maker, and having been cleansed from dirt are taken out and steamed over a slow fire for two days, a little clean stone lime being sprinkled through the bark. It is then steeped in water in earthen jars, and more lime is added. After a few days it is taken out of the jars, and having been well washed to free it from the lime, it is beaten with a mallet until it becomes a mass of soft pulp. A frame of netting, about six feet long, and of width varying from eighteen to five inches, is set afloat in water, and the pulp having first been again mixed up in water is skilfully poured out on to the frame so as to be equally distributed over it. The frame is then lifted out of the water and a small wooden roller is run over the surface of the pulp. By this process the water is squeezed out and the pulp pressed together. The frame, with the pulp on it, is then set to dry in the sun, and in the course of about ten hours it is quite dry, and the sheet of paper is then lifted off the frame. The surface is then smoothed by applying a thin paste of rice flour, and then rubbing it with a smooth stone. A black paper which is written on with a slate pencil is made by colouring the surface with a mixture of charcoal. The paper-making industry in Siam is burdened by a heavy tax varying from 7 per cent. on the best quality of paper to 100 per cent. on the commoner sorts. Native manufacturers are but few, and in consequence of this heavy impost the industry itself cannot develop to any considerable extent.

TEXTILE INDUSTRY OF TURKEY IN ASIA.

The *Moniteur des fils et tissus* reproduces a report from M. Savoye, French Vice-Consul at Homs, dealing with this subject. The looms used are of primitive simplicity, and cost but little. The principal changes in the trade during centuries have only consisted in the substitution of English white and coloured yarns, and German red yarns, for those of native manufacture previously in use, which were also exported to Europe. The introduction of aniline dyes is another recent improvement. The town of Homs is one of the most important centres of Syrian industry, its manufactures employing 4,000 looms, of which about 2,200 are engaged in the production of pure cotton goods, striped coloured materials, and striped Tripoli beltings known as *dima*. This branch of manufacture has considerably increased at Homs (where ten years ago it only occupied 400 looms), owing to the increased value of labour at Damascus and Aleppo, the other centres of textile manufacture in the country, where rich materials have acquired greater importance than elsewhere. About 400 looms are engaged in the production of a gauze composed of silk and cotton.

Hama is another centre of textile manufacture, where bath towels of cotton and silk are made, as well as felts and striped materials for mantles. The total value of the raw materials annually employed by the two towns, Homs and Hama, is about £190,000, and the yearly value of their joint productions is estimated at £380,000.

PRODUCTION OF SALT IN MEXICO.

Consul Mahlo, of Manzanillo, says that salt is a very important factor in the trade of the State of Colima, about 20,000,000 pounds being produced annually, partly along the coast of the Pacific, but principally on the borders of a shallow lagoon called the *Laguna de Cuyntlan*, which stretches twenty miles inland from Manzanillo. During the rainy season this lagoon is full of water, covering a large extent of low muddy ground. In the dry season hundreds of acres of its upper reaches and the shallow places are laid bare, and the dry mud quickly becomes covered with a crust of fine salt crystals. In the month of April the gathering of this large salt crop commences. The ground, earth and salt together, to a depth of from one-and-a-half to two inches, is scraped in heaps, and men, women, and children carry this mass to a filter in baskets. This filter is constructed of different layers of brush woods and branches of trees four to six feet thick, on the top of which the mass is deposited. Water is then poured over it with the object of dissolving the salt, and it flows slowly down into a deep trench below the filter while the earthy matter remains in the brush work. From the trench the deposit is taken and poured into large shallow basins four to six inches deep, constructed of common mortar for evaporation by the tropical sun. The process of crystallisation quickly commences, the white salt crystals first appearing on the surface, and then sinking to the bottom. The crystallisation having been completed, the salt is scraped together and taken out, it is put into sacks containing about one hundred and fifty pounds each, and is ready for the market. There are thousands of labourers employed on these salt fields during the harvest which lasts about three months.

Obituary.

Right Hon. Lord Henry Lennox.— Lord Henry Charles George Gordon Lennox, who held the office of Chairman of the Council of the Society of Arts from 1868 to 1871, died on Saturday, 28th inst., at his residence near Chichester. He was the third son of the fifth Duke of Richmond, and was born at Goodwood in 1821. He was educated at Westminster School and at Christ Church, Oxford, where he graduated. He sat for Chichester from 1846 to 1885, and during this period he was several times in office, as Lord of the Treasury in 1852 and 1858-59, as Secretary to the Admiralty in 1866-68, and as Chief Commissioner of Works, 1874-76. He was elected a member of the Society of Arts in 1861, and vice-president from 1862 to 1873. On January, 24th, 1866, he read a paper before the Society "On the Uses of National Museums to Local Institutions," at which meeting Mr. (now Sir) Austen Henry Layard presided. During his chairmanship Lord Henry Lennox took an active part in the work of the Society, and he frequently promoted its objects from his place in Parliament.

General Notes.

Silk Production of the World in 1885.— According to a pamphlet recently published by the *Sindicat de l'Union des Marchands de Soie* of Lyons, of the total quantity of silk produced in the world in 1885, 36 per cent. was furnished by Europe; 7 per cent. the Levant; and 57 per cent. by India, China, and other countries of the East.

Chain Towage on the Maine. — The *Norddeutsche allgemeine Zeitung* states that a chain is being laid in the River Maine, above Schaffhausen, in order to render the navigation of this river possible for large barges. Up to the present time it has been laid up for a distance of about 52 miles, as far as Oberrad, above Frankfort, and by the end of the month it is anticipated that the operation will be completed as far as Magonza. The tugs will be of 130 horse-power, and with a draught not exceeding 52 centimetres (20½ inches).

Barcelona Exhibition.—It has been arranged by the Spanish authorities to hold an International Exhibition at Barcelona, from September, 1887, to April, 1888, to include agriculture, industries, commerce, public instruction and liberal arts, marine, fisheries, pisciculture, fine arts, electricity, medicine, and hydropathy. Foreign Governments will be invited to be officially represented by means of Commissions appointed for the purpose. The necessary measures will be adopted in order to protect in Spain those inventions capable of being patented, drawings and models, as well as industrial trademarks of goods represented in the Exhibition. The exhibitors, both Spanish and foreign, will have to pay rent for the space or site which they occupy. An international jury will be appointed for the purpose of adjudging the awards. These awards will consist of diplomas of honour, gold, silver, and bronze medals, and honourable mentions. All communications relating to the Exhibition should be made by prepaid letter to the Junta Directiva of the International Exhibition of Barcelona, and directed "Oficinas del Parque."

Division of Land in Germany.—In Germany the extent of land devoted to agriculture amounts to 78,405,000 acres; apportioned into holdings of 2½ acres and less, 1,950,000 acres; of 2½ to 25 acres, 20,225,000; of 25 to 250 acres, 37,000,000; of 250 acres and more, 19,000,000; comprising meadow land, 14,000,000; cereal, vineyard, and gardening land, 64,000,000, viz., cereals and vegetables, 47,000,000; fodder, 6,000,000; pastures, 8,100,000; gardening, 1,030,000; vintage, 335,000; rape, 330,000; flax, 270,000; hemp, 37,000; hops, 112,000; sugar beet, 837,000; and chicory, 25,000 acres. The area of land occupied by houses, yards, roads, and highways, and covered by streams, amounts to 6,800,000 acres, and the extent of pasture, heath and poor land is 12,000,000 acres. Forests and woods cover an area of 34,000,000 acres, distributed as follows—deciduous 12,000,000 acres, and coniferous 22,000,000 acres. The following is the number of farms and farm lots into which the whole of the 64,000,090 acres of arable land is divided—of 2½ acres and less, 2,323,316; 2½ to 25 acres, 2,274,096; 25 to 150 acres, 653,941; 150 acres and more, 24,991; total, 5,276,344.

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All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

NOTICES.

"OWEN JONES" PRIZES, 1886.

This competition was instituted in 1878, by the Council of the Society of Arts, as trustees of the sum of £400, presented to them by the Owen Jones Memorial Committee, being the balance of subscriptions to that fund, upon trust to expend the interest thereon in prizes to "Students of the School of Art who, in annual competition, produce the best design for Household Furniture, Carpets, Wall-papers, and Hangings, Damask, Chintzes, &c., regulated by the principles laid down by Owen Jones." The prizes are awarded on the results of the annual competition of the Science and Art Department.

Six prizes were offered for competition in the present year, each prize consisting of a bound copy of Owen Jones's "Principles of Design," and a Bronze Medal.

The following is a list of the successful candidates for the present year:—

1. Margaret E. Jones, School of Art, Cavendish-street, Manchester.—Design for a carpet and border.
2. Hollins Allen, School of Art, Warrington.—Design for a stair-carpet.
3. Walter Clarke, School of Art, Macclesfield.—Design for a silk hanging.
4. John Cassidy, School of Art, Cavendish-street, Manchester.—Modelled design for a panel.
5. Helen Lomax, School of Art, Cavendish-street, Manchester.—Design for printed cotton.
6. Lehmann Oppenheimer, School of Art, Cavendish-street, Manchester.—Design for the decoration of a mineral spring-well room.

Proceedings of the Society.

CANTOR LECTURES.

THE MICROSCOPE.

By John Mayall, Jun.

Lecture II.—Delivered November 30, 1885.

Modern Microscopes to the Date of the Application of Achromatism (Continued).

Hooke's Microscopes.—We now arrive at a specially interesting date in the early history of the microscope—the publication of Hooke's compound instrument, in 1665, in his "Micrographia," whence my Fig. 13 (p. 1008) is reproduced.

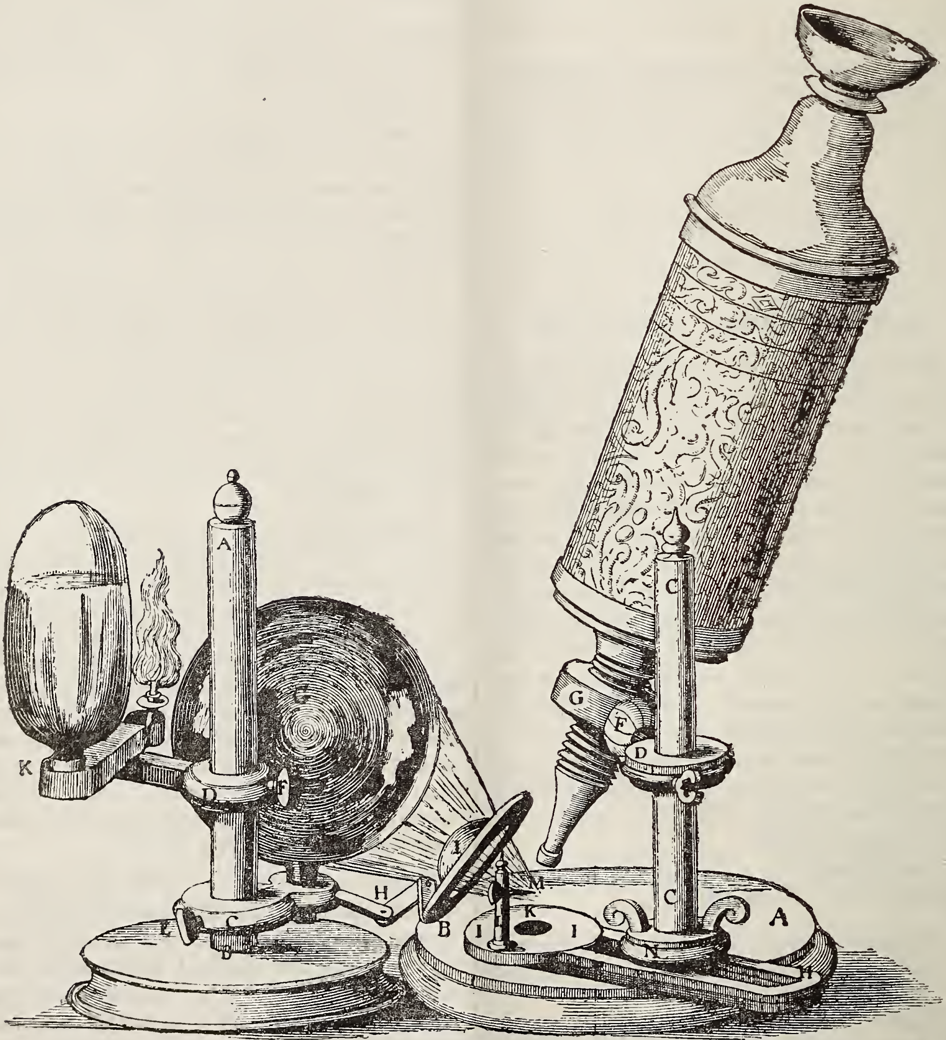
Hooke's first claim is for the application of a powerful illuminating apparatus, consisting of a lamp adjustable on a standard, with a globe of water and a deep plano-convex condensing lens on moveable arms, by which the light could be directed as required on the object. He thus describes his method of using sunlight:—

> "I place a small piece of oyly Paper very near the Object, between that and the light; then with a good large Burning-Glass I so collect and throw the Rayes on the Paper, that there may be a very great quantity of light pass through it to the Object; yet I so proportion that light, that it may not singe or burn the Paper. Instead of which Paper there may be made use of a small piece of Looking-glass plate, one of whose sides is made rough by being rubb'd on a flat Tool with very fine sand, this will, if the heat be leisurely cast on it, indure a much greater degree of heat, and consequently very much augment a convenient light." (Pref., pp. 16-7).

These suggestions all point to Hooke's practical ability in the actual use of the microscope. He notes very clearly the advantage of employing this diffused light rather than direct sunlight, for "when the immediate light of the Sun falls on" an object, "the reflexions from some few parts are so vivid, that they drown the appearance of all the other, and are themselves also, by reason of the inequality of light, indistinct, and appear only radiant spots." (*ib.*, p. 17). On comparing these practical remarks of Hooke's with Descartes' advice on the same point, namely, to condense direct sunlight on the objects, I am confirmed in my opinion that Descartes had probably not used his microscopes as he recommended.

Hooke describes his microscope in detail, commencing with his application of four draw-tubes for lengthening the body, which was normally "not above six or seven inches long." Then he explains his addition of a third lens to the optical combination, whence we infer that previously the compound microscopes contained two lenses only—an object-lens and an eye-lens. This third lens was applied in a cell on the top of the cylindrical tube, so as to be readily removed; he used it, as he states, "only when I had occasion to see much of an Object at once; the middle Glass [field-lens] conveying a very great company of radiating Pencils, which would go another way, and throwing them upon the deep Eye Glass. But when ever I had occasion to examine the small parts of a Body more accurately, I took out the middle Glass, and only made use of one Eye Glass with the Object Glass" (*ib.*, p. 22).

FIG. 13.



HOOKE'S COMPOUND MICROSCOPE (1665).

How far Hooke's application of a field-lens to the eye-lens of a microscope may have been suggested by the invention of the compound eye-piece associated with the name of Huyghens* (though attributed by some authorities to Campani), I cannot determine. In any case, the sole purpose Hooke had in view, according to his own statement, was to increase the size of the field of view, and had nothing to do with correcting the spherical aberration of the eye-lens. His plain admission that he removed the field-lens when he was seeking the best definition is conclusive on this point.

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* In the notice of Huyghens in the "Biographie Universelle," it is stated that he applied "une combinaison de deux oculaires" to his telescope previous to 1659, *i.e.*, some years before the publication of Hooke's application of a field-lens to the microscope.

From the description of the mechanism of this microscope, given by Hooke, I think he intended to claim the general design. The ball-and-socket movement of the body to the arm-carrier is thus described:—

> "On the end of this Arm [D, which slides on the pillar C C] was a small Ball fitted into a kind of socket F, made in the side of the Brass Ring G, through which the small end of the Tube was screw'd; by means of which contrivance I could place and fix the Tube in what posture I desir'd (which for many Observations was exceeding necessary) and adjusten it most exactly to any Object" (*ib.*, p. 23).

The ball-and-socket movement, as here applied, is certainly not advantageously situated. In the microscopes I have met with constructed on Hooke's general design, this movement was replaced by a strong short screw attached to the ring, G, and fitting in a corresponding screw-socket projecting from, and forming part of, the sliding arm, D; this screw arrangement permitted the lateral inclination of the body-tube, and a thumb-screw at the side of the screw-socket clamped it in position. In several figures of Hooke's microscope, published since 1665, this modification is shown; for instance, in Sturm's "Collegium Curiosum" (1676), Fig. LXX., and in Zahn's "Oculus artificialis" (1685), which we shall examine.

It would appear that Hooke's introduction of the ball-and-socket in the construction of the microscope has met with numerous advocates since; it may not be uninteresting to cite a few examples by way of illustration.

J. Musschenbroek (1702) applied three of these movements, as articulations, to his simple microscope. Marshall (1704) used a large one with a tightening collar at the lower end of the standard to his compound form. Joblot (1718) had three on his simple lens-carrier; and Lyonet applied five to his. Culpeper (about 1730) mounted Wilson's simple, and his own application of the compound to the same, on a ball-and-socket, with adjustment on the top of the standard. B. Martin (1742) used it similarly with his first form of "Universal Microscope." Adams, Jones, Dollond, Pyefinch, Bates, and other English makers of the latter part of the last, and early part of this century, used a sort of chain composed of ball-and-socket joints to carry forceps, &c. A greatly improved form, with a powerful clamp, was devised by Goring to support his "Engiscope" on the top of the standard (*vide* Fig. and description in Pritchard's "Microscopic Illustrations," London, 1830, royal 8vo). More recently we have had stage-movements (by Varley, Powell and Lealand, Smith and Beck, Dancer, and others) controlled by ball-and-socket attached to a lever; in one instance—Varley's small model—two such levers acting together were applied. Microscope-lamps, mirrors, condensers, side-reflectors, illuminating prisms, forceps, and cameræ lucidæ, have all been fitted with ball-and-socket movements. The high-water mark of the application is probably reached in Marten's "Ball-Jointed Microscope,"* in which two of these movements are applied to carry the body-tube, and the stage is a hemisphere moving in a hemispherical cup, specially devised for the examination of large specimens of metals, &c., that cannot be readily viewed by an ordinary microscope.

The facility of movement provided by the ball-and-socket joint would seem to have attracted the notice of designers of microscopical appliances in every generation since its introduction by Hooke. For small accessories, where the leverage need not be considered, the ball-and-socket is convenient, though its use demands, in general, more manipulative skill than is required with the usual pivot mechanism; but it should not be applied as the main support of the inclining movement of the body of a large microscope. Even when made with a powerful clamp, as Goring devised, there is always the risk that when the clamp is released, the instrument may capsize through negligence in handling.

Hooke also explains minutely the construction of the object-stage thus:—

> "For placing the Object, I made this contrivance; upon the end of a small brass Link or Staple HH, I so fastned a round Plate II, that it might be turn'd round upon its Center K, and going pretty stiff, would stand fixt in any posture it was set; on the side of this was fixt a small Pillar P, about three quarters of an inch high, and through the top of this was thrust a small Iron pin M, whose top [pointed

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* "Zeitschr. f. Instrumentenk," ii. (1882), p. 112 (Fig. 1.), reproduced in "Journ. Royal Micr. Soc.," ii. (1882), p. 672; the stage was not figured.

end] just stood over the Center of the Plate; on this top I fixt a small Object, and by means of these contrivances I was able to turn it into all kind of positions, both to my Eye and the Light; for by moving round the small Plate on its center, I could move it one way, and by turning the Pin M, I could move it another way, and this without stirring the Glass at all, or at least but very little: the Plate likewise I could move to and fro to any part of the Pedestal (which in many cases was very convenient) and fix it also in any Position, by means of a Nut N, which was screw'd on upon the lower part of the Pillar CC" (*ib.*).

This object-stage seems to me based on sound practical ideas—ideas that have only been duly appreciated in our own time, as shown by the now general application of the rotating stage, which our ancestors almost totally ignored. The link clamped down upon the base was an admirably steady support for the rotating plate, far superior to the generality of stage devices contrived before the system developed by Oberhaeuser was employed (about 1830).

Hooke appears to have been dissatisfied with the lenses he used. He says:—"The Glasses I used were of our English make, but though very good of the kind, yet far short of what might be expected, could we once find a way of making Glasses Elliptical, or of some more true shape." He complains that the "Apertures of the Object-glasses are so very small, that very few Rays are admitted, and even of those few there are so many false, that the Object appears *dark* and *indistinct*....." Of the "best Glasses," he states that "none will admit a sufficient number of Rayes to magnifie the Object beyond a determinate bigness" (*ib.*, p. 16). To remedy the inconvenience due to the want of light transmitted by the microscope he devised the lamp and condensers described above to illuminate the object more powerfully.

It is evident that Hooke discovered thus early the importance of increasing apertures; but the greater apertures he had in view were merely to provide a greater quantity of light from the object to enable him to get higher magnification—the magnification he aimed at being limited by the want of light. He says nothing, nor could he be expected to say anything, regarding any increase of resolving power by the increase of aperture, for the connection between aperture and resolving power could hardly have been seriously considered from any practical point of view, in the construction of either dioptric telescopes or microscopes, before the application of achromatism.

We may infer that other large microscopes were in use at that date, for Hooke states that a blown-glass globule,* prepared and used as he describes, will "make some Objects more distinct then any of the great *Microscopes*" (*ib.*, p. 22). It would appear also that the viewing transparent objects by transmitted light was not yet discovered to be the principal utility of high powers, for Hooke, in explaining that "the larger the Telescope Object Glasses are, and the shorter those of the Microscope, the better they magnifie," qualifies the statement (as relating to the microscope) by adding that it will be exceeding *difficult* . . . to *inlighten* an Object less then an hundred part of an inch distant from the Object Glass" (*ib.*, pp. 19-20). Clearly, then, Hooke thought only of viewing opaque objects with high powers. The difficulty he notes with reference to the illumination would not apply to transparent objects. A proximity of one hundredth of an inch would be no serious obstacle to viewing objects by transmitted light, and would certainly not impose a limit (such as he implies) to the magnification.

Hooke also describes a compound microscope he devised to have two refractions only, consisting of a conical tube, at the small end of which he cemented a plano-convex lens of short radius, with its convex surface outwards, for the object lens, and at the larger end he cemented similarly a larger lens of greater radius; then, by means of a small hole in the side, he filled the tube with water, stopping the hole with a plug. With this arrangement, he states, "I could perceive an Object more bright then I could when the intermediate space was filled with Air, but this, for other inconveniences, I made but little use of" (*ib.*, p. 23).

He also made other forms of microscopes, some of "Waters, Gums, Resins, Salts, Arsenick, Oyls, and with divers other mixtures of watery and oyly liquors" (*ib.*); he adds, "I find generally none more useful then that which is made of two Glasses, such as I have describ'd" (*ib.*), thus leaving his invention of the "Middle Glass," or field-lens, to take care of itself.

Hooke was, I believe, the first to describe a useful method of estimating the magnifying power of a compound microscope. He says:—

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* Poggendorff ("Hist. de la Physique," p. 357) states that in the production of minute lenses of blown-glass globules Hooke was preceded by Toricelli.

> "Having rectifi'd the *Microscope*, to see the desir'd Object through it very distinctly, at the same time that I look upon the Object through the Glass with one eye, I look upon other Objects at the same distance with my other bare eye; by which means I am able, by the help of a *Ruler* divided into inches and small parts, and laid on the *Pedestal* of the *Microscope*, to cast, as it were, the magnifi'd appearance of the Object upon the Ruler, and thereby exactly to measure the Diameter it appears of through the Glass, which being compar'd with the Diameter it appears of to the naked eye, will easily afford the quantity of its magnifying" (*ib.*, p. 22).

This method is, obviously, applicable only to objects that can be plainly discerned by the unaided eye.

Hooke was one of the earliest to note upon the difficulty of distinguishing between a "prominency and a depression" with the microscope (pseudoscopy), which he states that he observed when preparing the drawings for the illustrations of his "Micrographia," which would be in 1664, if not earlier. Prof. Govi,* in his work on the "Discoverer of a Singular Optical Illusion," refers to a printed letter of Eustachio Divini to Count Carlo Antonio Marozini, dated 15 July, 1663, in which certain phenomena of pseudoscopy are described; Divini may, therefore, have preceded Hooke in these observations. I remark, in passing, that Divini refers in this letter to "Microscopes with two glasses," and states that when he wanted to see the whole of rather large objects he removed the deep object-lens and substituted a lens of shallower curvature; but, apparently, he knew nothing at that date of the use of a field-lens in the ocular; this would appear to confirm indirectly Hooke's claim to be the first to apply a field-lens to the ocular of a microscope.

The series of drawings of common objects, such as a needle point, a razor edge, snow crystals, spiders, and other insects, &c., as seen under his compound microscope, were doubtless viewed with much astonishment by many of Hooke's contemporaries, and his "Micrographia" soon became a scarce and expensive book. In the descriptions of these objects he touches incidentally upon an enormous mass of details regarding microscopical manipulations, &c., details evincing great industry and acuteness of observation.

In his "Lectures and Collections," published in 1678, under "Microscopium," pp 96-7, we find Hooke no longer advocating the "double" microscope in his former enthusiastic tone. Whether this change of opinion was due to the publication of Leeuwenhoek's successful observations with simple microscopes I cannot determine. Hooke has been suspected by many who have sought to inform themselves of the history of his contributions to science, of being somewhat over-anxious to keep himself to the fore; but this must not prevent our acknowledgement of his real merits. He states that in using plano-convex lenses as single microscopes, "'tis best to turn the plain side towards the object, and the convex to the eye;" and that he himself had not used any less than 1-10th inch in radius of curvature, because they strained his sight, "though in truth they do make the object appear much more clear and distinct, and magnifie as much as the double Microscopes: nay, to those whose eyes can well endure it, 'tis possible with a single Microscope to make discoveries much better than with a double one, because the colours which do much disturb the clear vision in double Microscopes is clearly avoided and prevented in the single."

Hooke must undoubtedly be credited with the first suggestion of immersion lenses, thus:—

> "If further, you would have a Microscope with one single refraction, and consequently capable of the greatest clearness and brightness that any one kind of Microscopes can possibly be imagined susceptible of, when you have fixt one of these little Globules as I have directed [globules of blown-glass, the preparation of which he had described], and spread a little of the liquor upon a piece of Looking-glass plate, then apply the said plate with the liquor, next to the Globule, and gently move it close to the Globule, till the liquor touch; which done, you will find the liquor presently to adhere to the Globule, and still to adhere to it though you move it back again a little; by which means, this liquor being of a specifique refraction, not much differing from glass, the second refraction is quite taken off, and little or none left but that of the convex side of the Globule next the eye; by which means as much of the inconvenience of refraction as is possible is removed, and that by the easiest and most practicable expedient that can be desired" (*ib.*, pp. 98-9).

The criticism I have made on Campani's screw-focussing adjustment applies still more to Hooke's microscope, for here the body-tube, being much longer and heavier, would be certain to describe series of "curves of irregular curvature" round about what should be the rigid optic axis in the screw-movement of focussing, the object, if small, appearing in the field or disappearing according to the erratic nature of the screw-fitting—the screw-fitting as made at that date.

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* "Atti R. Accad. Lincei. Transunti," vii. (1883), pp. 183-3.

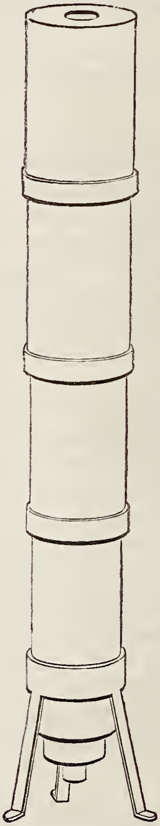
Nothing is said about the application of a mirror, nor have I met with any microscope, provided with a mirror, of date anterior to about fifty years later than Hooke's instrument, *i.e.*, 1710-1720.

Hooke appears to have entrusted the manufacture of his microscopes for sale to "Mr. Christopher Cock, in Long-Acre" (*ib.*, p. 99).

I have dealt somewhat fully with Hooke's microscopes, but not more fully than I think they deserve in view of the fact that he was the first to give a real impetus to English microscopy in the two main branches in which it is divided—the optical and mechanical construction of the instrument, and its application to research—in both of which his influence was conspicuous. It would be an easy task to prove, by citations from the contemporary scientific publications, that Hooke's work as a microscopist gained him European fame. For my own part, I can never forget that one of the most eminent men of science of our day, one whose competence to form a fair and accurate judgment is beyond question—I allude to Herschel—has referred to Hooke as "the great contemporary, and almost the worthy rival of, Newton" ("Discourse on Nat. Philos.," p. 116).

Divini's Microscope.—Soon after the publication of Hooke's compound microscope, we find in the "Giornale de Letterati," I. (1668), pp. 52-4, a description (partly translated in "Philos. Trans.," III., 1668, p. 842) of a compound microscope constructed by Eustachio Divini, which had already been commended by by Fabri, in Prop. 46 of his "Synopsis Optica" (1667). It was stated to be about 16½ inches high, and adjustable to four different lengths by draw-tubes, giving a range of magnification from 41 to 143 diameters. Instead of the usual bi-convex eye-lens, two plano-convex lenses were applied with their convex surfaces in contact, by which he claimed to obtain a much flatter field. In the Museo Copernicana, at Rome, there is a microscope answering to this description so closely that I think we may safely refer its origin to Divini. I made a sketch of it, from which my Fig. 14 has been copied. The tripod base terminating above in a cylindrical socket is of tin; the body-tubes are of cardboard covered with grey paper, and the magnifications of the various lengths are noted on each tube. The lowest tube slides within the metal socket of the tripod, and carries the object-lens in a thin cell of tin slid on the end; the next tube slides over the former, and has an external collar at the lower end, apparently to serve as a stop to the next tube; the third and fourth tubes are similar, but progressively larger, and a diaphragm is at the upper end. As regards the optical construction, my impression is that it has been tampered with, and I question if anything of the original remains.

FIG. 14.



DIVINI'S COMPOUND MICROSCOPE (1667-8).

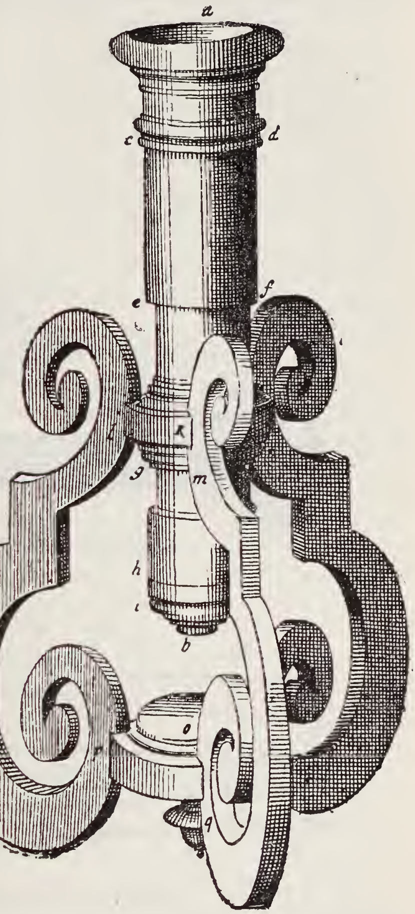
I may mention that in Birch's "Hist. of the Royal Society," a passage (*vide* Prof. Govi, *loc. cit.*) is quoted from the official papers of the Society, dated 11th February, 1668-9, showing that a large microscope (probably of Hooke's general design), made by Mr. Christopher Cock, was to be brought to the Society at the next meeting. This microscope had "five glasses, of which four eye-glasses were plano-convex, two and two so put together, as to touch one another in a point of the convex surface." The eye-piece was thus a modification of that of Divini; whence it would appear that our opticians were alert in seeking improvements. We shall see later on that Grindl (1687) adopted this eye-piece, and applied a similar construction to the objective.

Chérubin d'Orléans' Microscopes.— The next microscope in order of date we shall examine was designed by Chérubin d'Orléans, and published in his treatise, "La dioptrique oculaire," in 1671 (Paris, fol., Plates 30-1, pp. 238 and 261), *vide* my Fig. 15. Chérubin evidently had a high opinion of his microscope, giving minute instructions for its construction with detailed figures. The three "consoles," or scroll supports, were to be of ebony or blackened pear-tree, firmly attached to the base and to the collar encircling the fixed central portion of the body-tube. An exterior sliding tube carried the ocular above on the fixed tube, and a similar sliding tube carried the object-lens below, the sliding tubes serving to focus the image and regulate within certain limits the magnification. He further suggested and figured a screw arrangement to be applied beneath the stage for focussing, the optical body in this case to consist of two tubes only, and the object-lens remaining stationary.

Chérubin also described and figured a stage-disc on which several objects were to be mounted concentrically, and this disc was to be attached to rotate on the focussing stage, so that objects could be viewed successively in the optic axis by the mere rotation of the disc. He was thus probably the inventor of the multiple object-disc, modifications of which have had some vogue in our own time, both in Europe and America, and even in Japan, as we shall see later on. He also figured spring forceps, and a "stab" on articulated joints, to hold insects, &c.

With regard to the optical arrangement of this microscope, Chérubin recommends so many different combinations of lenses that I cannot determine with certainty which he really preferred. His recommendations embody so many items as to remind one forcibly of certain modern specifications of patents, in which it is sought to include every possible (not to say impossible) combination within the sphere of the invention. At p. 217, in referring to a microscope composed of two convex lenses, he states that the object-lens may be $\frac{1}{4}$, $\frac{1}{3}$, or $\frac{1}{2}$ inch focus at most, and equi-convex. "Its eye-glass, not requiring to be far from the objective, must be of a rather larger sphere, for instance, about $\frac{3}{4}$, 1, or $1\frac{1}{2}$ inch focus at most." Another construction, which he states (pp. 220-1) he actually made, contained a second lens in the ocular, having a focus in relation to the eye-lens as $2\frac{1}{2} : 1$, or $3 : 1$; and his remarks on the effects observed by placing the field-lens too near to, or too far from, the eye-lens seem based on actual experience. He notes upon the combinations of three and four separate lenses, by which objects may be seen in their natural position (erect), and states that the latter is "much to be preferred" (p. 264).

Fig. 15.



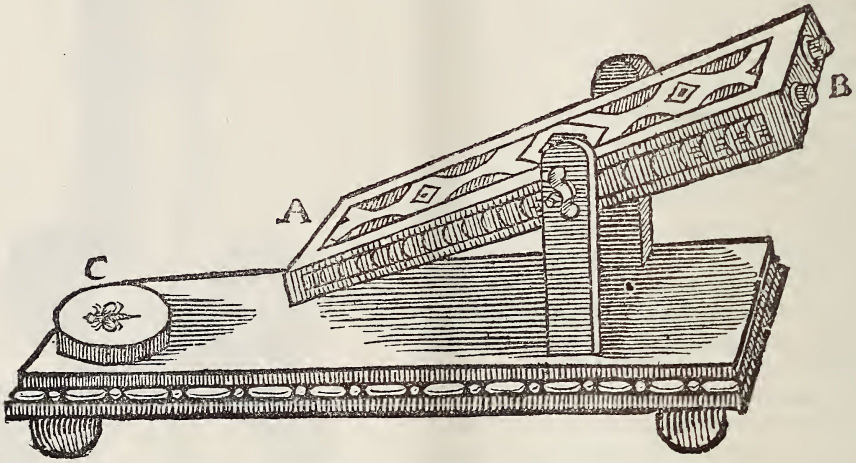
Chérubin d'Orléans' Compound Microscope (1671).

Chérubin d'Orléans' Binocular Micro-

scope.—Chérubin d'Orléans is generally believed to be the inventor of the binocular microscope, which he published in his work "La vision parfaite," in 1678 (Paris, fol., also the same work freely translated into Latin by himself, "De visione perfecta," Paris, 1678, fol.), and which he states that he actually constructed some years previously, and submitted to the inspection of several of his friends (*vide* Pref., p. viii). His device consisted of two compound microscopes, joined together in one setting, so as to be applicable to both eyes at once; a segment of each object-lens (supposed to be of one inch focus) was ground away to allow the convergent axes starting from the two eyes to meet at about 16 inches distance, at the common focus. Mechanism was provided for regulating the width of the axes to correspond with the observer's eyes.

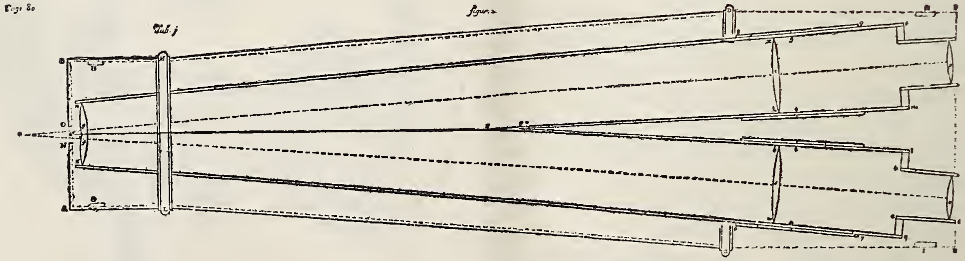
A drawing of this binocular, as known to Zahn, was given in the first edition of his 'Oculus artificialis" (1685), and is here reproduced in Fig. 16. As here shown the only method of focussing was to move the object by hand. I have, however, met with a binocular made on Chérubin's system, constructed early in the 18th century according to the instructions given in "La vision parfaite," in which the mechanism was excellent. Fig. 17 showing the optical construction, is copied from the original diagram ("La vision parfaite," Tab. I., Fig. 2, p. 80). Hooke criticised the instrument with some asperity ("Lectures, Microscopium," pp. 101-2), probably because Chérubin stated it had enabled him to discover mistakes in certain recently published figures of microscopical objects (alluding to some of the drawings in Hooke's "Micrographia"). Hooke was obliged, however, to admit "failures in some of those draughts, some of my own and some of the gravers committing. *Humanum est.* But those which he [Chérubin] charges for such are not, as he might have seen if he had made use of better glasses than those which he describes, for they are so far short of equalling those I use, that I

FIG. 16.



CHÉRUBIN D'ORLÉANS' BINOCULAR MICROSCOPE (1678).

FIG. 17.



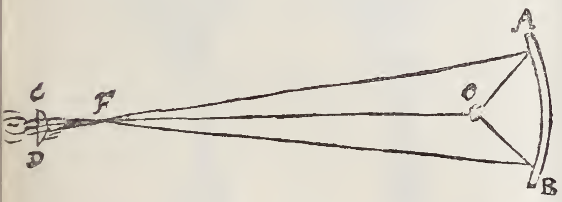
CHÉRUBIN D'ORLÉANS' BINOCULAR MICROSCOPE (1678).

can demonstrate from his own Description of them, that those I made use of did magnifie 10000 times more than that with which he pretends to have made these great Discoveries." Hooke's opinion was that objects are seen in the microscope far better "with one eye only [*i.e.*, the monocular microscope], which is much to be preferred before that with two [binocular]." And he asks the very pertinent question (which I think has not been satisfactorily answered even by the advocates of the binoculars of our own day), "what Discoveries he [Chérubin] doth make with his binocular Microscope more than was seen before."

Newton's Reflecting Microscope.—In 1672, Newton communicated to the Royal Society ("Phil. Trans." VI., 1671-72, p. 3080), a short note and diagram descriptive of his Reflecting Microscope—the first suggestion of a microscope acting by reflection—as follows :—

> "I have sometimes thought to make a *Microscope*, which in like manner should have, instead of an Object-glass, a Reflecting piece of metall. And this I hope they [the Royal Soc.] will also take into consideration. For those instruments seem as capable of improvement as *Telescopes*, and perhaps more, because but one reflective piece of metall is requisite in them, as you may perceive by the annexed diagram [reproduced in Fig. 18], where AB representeth the object metall, CD the eye-glass, F their common Focus, and O the other focus of the metall, in which the object is placed."

FIG. 18.



NEWTON'S REFLECTING MICROSCOPE (1672).

It does not appear that Newton ever had this microscope constructed. The modern instruments termed reflecting graphoscopes are equivalent to Newton's reflecting microscope in construction, except that they are not furnished with an eye-lens.

Leeuwenhoek's Microscopes. — In 1673, Leeuwenhoek commenced communicating his discoveries with the microscope to the Royal Society. Beyond the occasional statement that his observations were made with simple microscopes (as distinguished from the Keplerian compound instrument, for the "Galilean" combination seems to have almost drifted out of memory from its very early construction in the 17th century down to its re-advocacy by Brücke in this century), Leeuwenhoek explained nothing by which his contemporaries could furnish themselves with instruments like those he employed; and this silence added to the mysterious awe with which he and his work were regarded. He was extremely shy of exhibiting his microscopes to any one ; and some of his contemporaries taxed him with a greater love of praise than of truth because of his eagerness in claiming discoveries. Even as late as 1709 the real construction of Leeuwenhoek's microscopes was not certainly known (*vide* "Phil. Trans.," XXVII., pp. 24-27, "A letter from Dr. Archibald Adams to Dr Hans Sloane, R.S.Secr., concerning the manner of making microscopes, &c.," where Dr. Adams, after describing that "they appear'd to be spherules lodg'd between two plates of gold or brass, in a hole whose diameter might not be bigger than that of a small pin's head," adds, "but still their make and truth are unknown").

Now that we know exactly the kind of instruments Leeuwenhoek employed, there can be no difficulty in the admission that his reputation as a discoverer in microscopy was really based on his patience and dexterity in the preparation of his objects, and on the skill he brought to bear on the interpretation of his observations. As to his microscopes, their construction was of the rudest kind mechanically, whilst optically they consisted of simple bi-convex lenses with worked surfaces mounted between two thin metal plates with minute apertures through which the objects were viewed directly. At his death he bequeathed to the Royal Society a cabinet containing twenty-six of his microscopes, which were reported upon by Martin Folkes, Vice-President of the Society, in the "Phil. Trans.," XXII. (1723), pp. 446-63.

In 1740 these microscopes were examined, and reported upon to the Royal Society, by Henry Baker, F.R.S. ("Phil. Trans.," XLI., 1740, pp. 503-19), and it appears that they ranged in power from 1-20 to 1-5, magnifying from 160 to 40 diameters. In 1753 Baker gave two outline drawings representing both sides of one of these microscopes in his "Employment for the Microscope" (Pl. XVII., Figs. 7 and 8, pp. 434-6), whence my Figs 19 and 20 (p. 1016) are copied. The cabinet and the microscopes have disappeared from the Royal Society. Baker's description is as follows :—

"The Eye must be applied to the Side fig. 7 [my Fig. 19]. The flat Part A is composed of two thin Silver Plates fastened together by little Rivets *b b b b b b*. Between these Plates a very small double-convex Glass is let into a Socket, and a Hole is drilled in each Plate for the Eye to look through at *c*. A Limb of Silver *d* is fastened to the Plates on this Side by a Screw *e* which goes through them both. Another Part of this Limb, joined to it at right Angles, passes under the Plates, and comes out on the other Side (*Vid.* fig. 8 [my Fig. 20]) at *f*: through this runs, directly upwards, a long fine-threaded Screw *g*, which turns in and raises or lowers the Stage *h*, whereon a coarse rugged Pin *i* for the Object to be fastened to, is turned about by a little Handle *k*; and this Stage with the Pin upon it is removed farther from the magnifying Lens, or admitted nearer to it, by a little Screw *l*, that passing through the Stage horizontally, and bearing against the Back of the Instrument, thrusts it farther off when there is occasion. The End of the long Screw *g* comes out thro' the Stage at *m* [?], where it turns round, but acts not there as a Screw, having no Threads that reach so high."

FIG. 19.

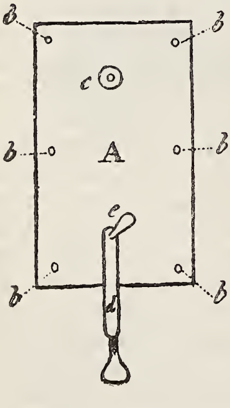
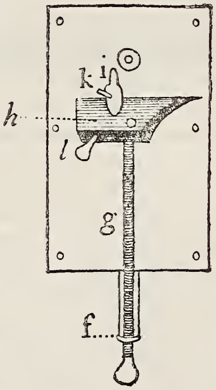


FIG. 20.



LEEUWENHOEK'S MICROSCOPE.

By the courtesy of Prof. Hubrecht, of Utrecht University, I am enabled to give figures of one of the Leeuwenhoek microscopes belonging to the Museum of that University; it is shown in Figs. 21 and 22 full size. The lens is bi-convex, of about 1-4th inch focus, and is mounted between two concavities provided with minute apertures, made in two corresponding thin plates of brass, which are held together by three rivets, two at the upper end, and one at the lower. The object is held in front of the lens, on the point of a short rod, the other end of which screws into a small block or stage of brass, which is rivetted somewhat loosely on the smoothed cylindrical end of a long coarse-threaded screw acting through a socket angle-piece attached behind the lower end of the plates by a small thumb-screw. The long screw serves to adjust the object under the lens in the vertical direction, whilst the pivoting of the angle-piece on its thumb-screw gives lateral motion. The object-carrier can be turned on its axis, as required, by screwing the rod into the stage. For focussing, a thumb-screw passes through the stage near one end, and presses vertically against the plates, causing the stage to tilt up at that end; the fitting of the long screw-carrier (angle-piece) is such that the stage at the end is sprung down somewhat forcibly on the brass plates, and it is against this pressure that the focussing screw acts. The metal knob on the object-carrier has a small projection, which appears to have been intended by Leeuwenhoek to fit in the hole beneath, in the brass plates, and thus retain the object opposite the lens.

FIG. 21.

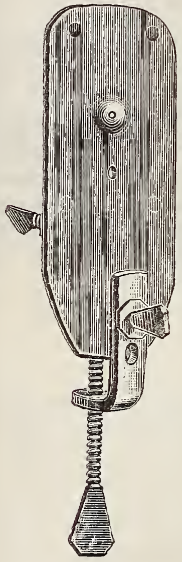
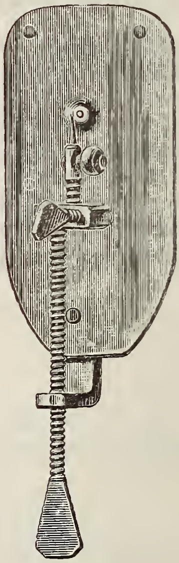


FIG. 22.

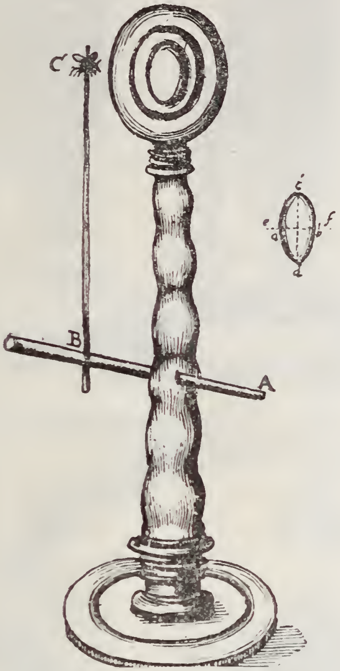


LEEUWENHOEK'S MICROSCOPE.

Simple Microscope (from Sturm's "Collegium curiosum").—A quaint form of simple microscope was figured in Sturm's "Collegium curiosum" (Norimb, 1676, 4to), p. 139, which is shown in Fig. 23 (p. 1017). The arrangement of the focussing rod AB is somewhat primitive—so primitive, indeed, that I suspect the design was of much older date. A section-view of the lens is shown.

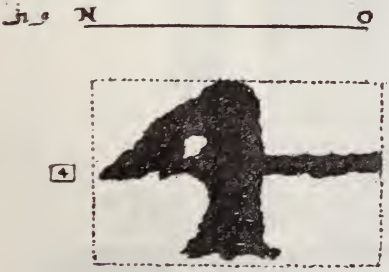
On the same page of the original work are two graphic representations (here shown in Fig. 24) of the magnifying power of this instrument; the one showing the line, *n o*, the original size, and the same magnified fourteen times linear to the size N O (but the draughtsman has exhibited the magnification in length only, not in breadth); the other showing the figure 4 as printed from type, and the same as magnified by the lens. Hooke had previously given a magnified view of a printed "full stop," with the original in juxtaposition; but he used a compound microscope. Sturm also gives a figure of Hooke's microscope as modified probably by one of the constructors who made it for sale; we shall presently come to a figure given by Zahn, almost identical with it.

Fig. 23.



Simple Microscope, from Sturm's "Collegium Curiosum" (1676).

Fig. 24.



Microscopes from Zahn's "Oculus artificialis."—The two editions of Zahn's "Oculus artificialis" (1st ed., Herbip., 1685, fol.; 2nd ed., Norimb., 1702, fol.) contain a considerable number of figures of curious microscopes, from which we may select a few.

(1.) *Early English Microscopes.*—In the first edition (1685), under the heading "Microscopii Anglicani" (Fundamentum III., p. 26), we find the six microscopes shown in Fig. 25 (p. 1018). Of these, *Figs.* 1 and 4* are early types of the fixed tripod support for the body-tube, which was developed by Culpeper and Scarlet some fifty years later into popular models that were taken up by the Nürnberg toy-makers of that date, and whose successors have continued to manufacture them in large numbers down to our own time. The original models generally had body-tubes of leather or parchment stamped and gilt, with supporting rings of wood. The tripods were of brass attached to wood bases. The lenses were mounted in wood or horn cells, sometimes with screw-rings to fix them, but generally with rings of bent wire sprung in; and caps were supplied to cover the eye-lens. These instruments mostly have large field-lenses; and in the early models the focussing by screwing the body-tube in a socket at the top of the tripod is nearly always met with; the sliding body-tube for focussing was rarely made until fifty years later. In *Fig.* 4 the rotating multiple object-disc appears. *Fig.* 2 shows two supports for the cross-bar in which the body-tube screws; but this model does not appear to have had much vogue. *Fig.* 3 seems to have been a modification of Hooke's model—a modification for the worse. *Fig.* 5 shows another form of rotating multiple object-disc forming the stage itself. *Fig.* 6 is another modification of Hooke's model; the stage is no longer carried on a link encircling the standard. This last instrument is practically identical with the one figured in Sturm's "Collegium Curiosum" to which I have already referred.

(2.) *Simple Microscope with Rotating Multiple Object-disc* (*anonymous*).—On p. 111 *(loc. cit.)* of the same work, Zahn figures

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* The numbering of these Figs.—1 to 6—is that of the original plate, which is reproduced in *facsimile*.

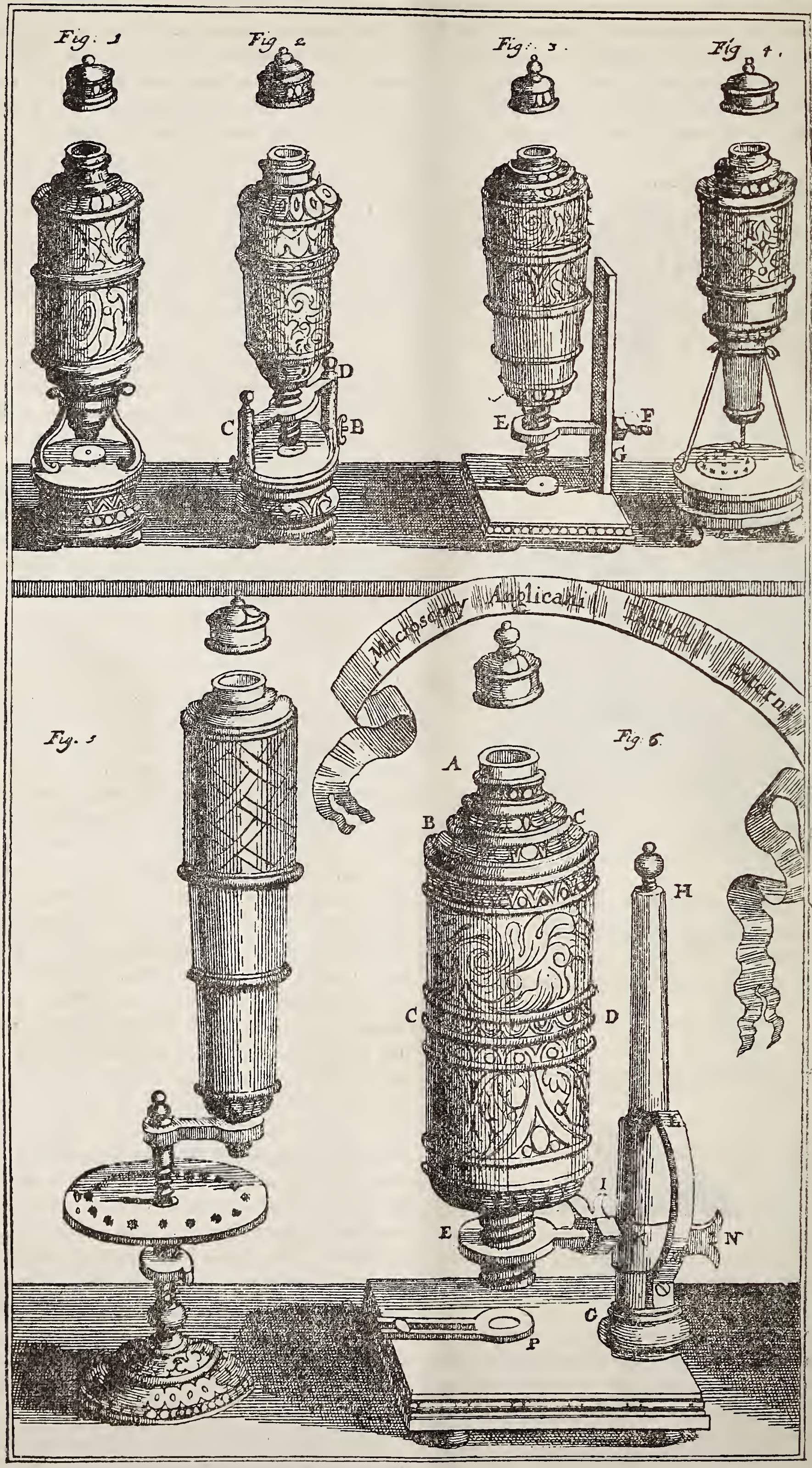
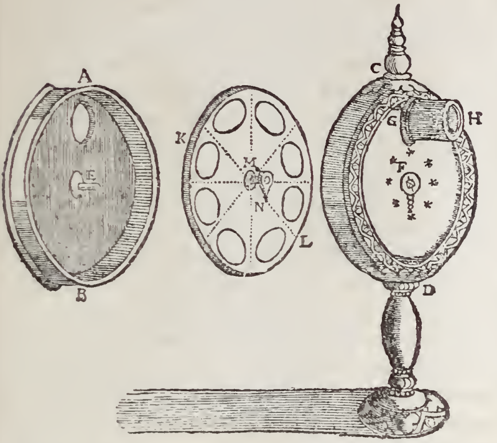


Fig. 25.—Early English Microscopes (1702).

a simple microscope with rotating multiple object-disc, shown here in Fig. 26.

Fig. 26.

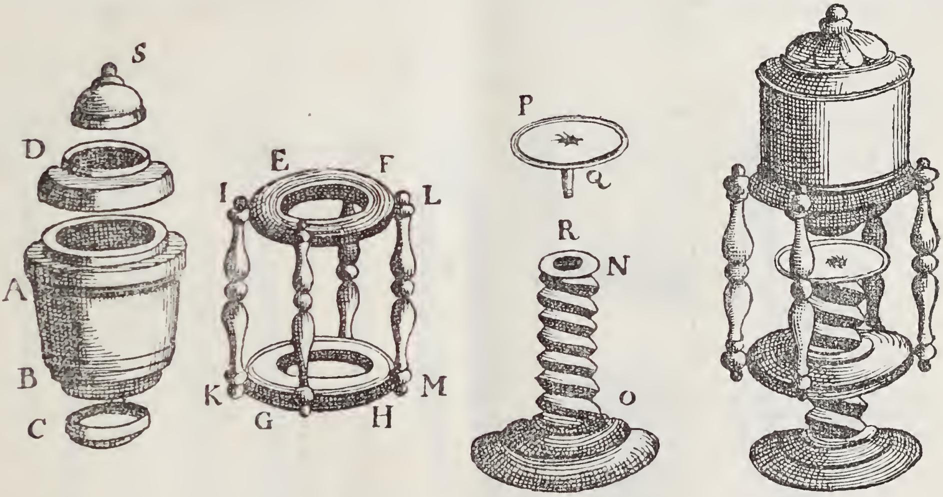


Simple Microscope with Rotating Multiple Object-disc (1685).

In the early days of the microscope, attention seems to have been given principally to opaque objects; this instrument, however, was designed to view transparent objects only. The disc, K L, was fitted to rotate on the pin, E, in the centre of the cap, A B, and this cap was applied within C D, so that the aperture would be opposite the lens-carrier, G H. The handle, N, served to rotate the disc, so that the objects passed successively in the field of view. Microscopes, more or less modified from this construction, were devised early in the 18th century by Joblot, who used high-power simple lenses, and hence had to provide delicate means of focussing. The system is still occasionally applied to "popular" microscopes.

(3.) *An "Augsburg" Microscope (anonymous.)*—In the 2nd ed. (1702) of the same work, p. 749, a small microscope is shown, which is reproduced in Fig. 27. I have termed it an "Augsburg" microscope, because the design is very like several other models which are known to have been constructed at Augsburg towards the close of the 17th century. From the number of instruments of this inferior class figured by Zahn, I think we may infer that the microscope was rapidly becoming vulgarised. The system of focussing by rotating the body by means of the socket travelling on the screw-standard must have been very defective in practice.

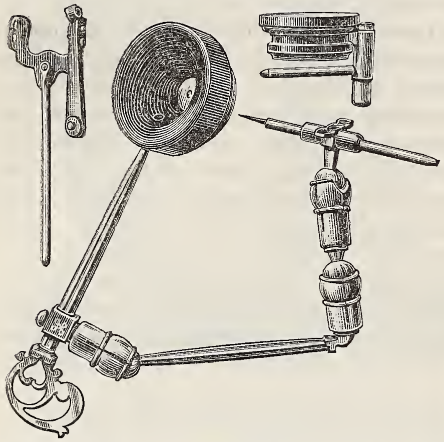
Fig. 27.



An "Augsburg" Microscope (1702).

(4.) *Musschenbroek's Simple Microscope.*—In the same work, p. 781, the first form of J. Musschenbroek's simple microscope is figured. My Fig. 28 (p. 1020) is a woodcut from a photograph of one of the original instruments belonging to the Museum of the University of Utrecht. We have here the first application known to me of ball-and-socket movements to a simple microscope to facilitate the examination of objects. We have noted above that Hooke first used it with his compound instrument. The carrier on the left served to hold pointed or forked rods on which objects were fixed, the rods passing through holes in narrow flanges at the sides, and being gripped by a pivoted spring, so that they could be turned as required, without slipping. The disc of wood on the right has a rod beneath, by which it can be slid in the socket that now carries the "stab," and it would then serve as a stage for minerals, &c.

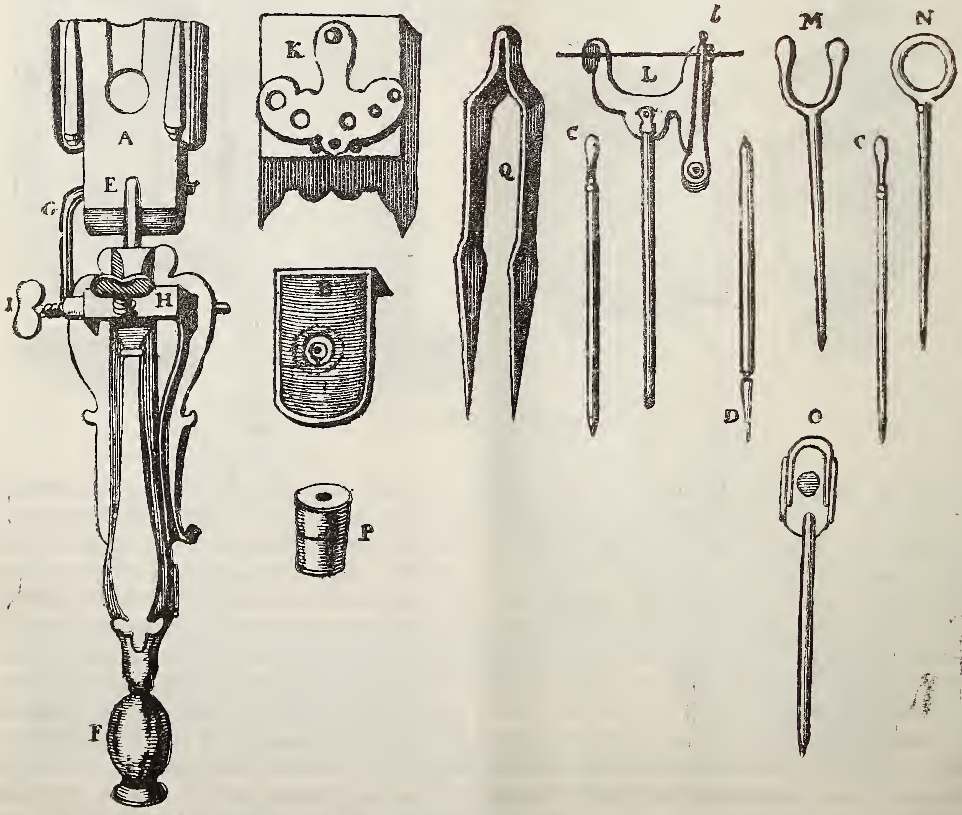
FIG. 28.



MUSSCHENBROEK'S SIMPLE MICROSCOPE (1702).

(5.) A much more elaborated form of Musschenbroek's simple microscope is shown in Fig. 29, copied from the original figure (*ib.*, p. 783). Here we have a hollow handle, through the length of which slides a tube, E, controlled by the knob, F; various forms of object-carriers, such as C, L, D, M, N, or O can be inserted at E; the handle is provided with hinge joints set at right angles, and by means of two thumbscrews, I and H, acting against the pressure of springs, the object can be moved laterally and adjusted to the focus of the lens. The lenses were bi-convex, mounted between two thin plates, B, of brass fitted to slide in metal grooves in the carrier, A, on the exterior of which slides the metal box, K, with its pivoted sector of diaphragms. G is a piece of wire bent to two right angles; one prong slides into a pivoted socket at the back of the instrument, the other passes laterally through A; by this arrangement the lens-carrier, A, can

FIG. 29.

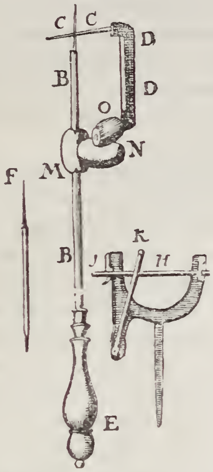


MUSSCHENBROEK'S SIMPLE MICROSCOPE (SECOND FORM, 1702).

be tilted forward or backward, or laterally, in relation to the object.

This system of changing-diaphragms, made by cutting them in a zone in a sector pivoted in its centre, is the first I have met with in connection with a microscope.

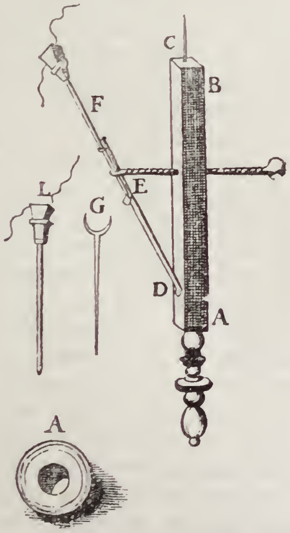
FIG. 30.



SIMPLE MICROSCOPE (MODIFIED FROM MUSSCHENBROEK'S, 1702).

The workmanship of Musschenbroek's microscopes is very neat and well finished, very superior to that of Leeuwenhoek's. As to the lenses, those I have had the opportunity of examining were about equal to his.

FIG. 31.



CUNO'S SIMPLE MICROSCOPE (1702).

(7.) Another form of simple microscope is shown in Fig. 30, which seems to have been partly copied from Musschenbroek's (*ib.*, p. 796). B B is the object-carrier on which slides the lens-carrier, C C, pivoted by the arm, D D, at O on the socket, M N.

(8.) *Cuno's Simple Microscope.*—Cuno's simple microscope is figured with the preceding whence my Fig. 31 is copied. The simplicity of this instrument would suggest that it may have been the original from which Musschenbroek, Wilson, and Lieberkühn devised their modifications. We shall meet with a still more primitive arrangement in an Italian work which we shall examine. The lens is mounted in the cell, A, fitting on the spike, C. The object is attached to the rod, F, or the fork, G, which are adjustable on the hinged arm, D; then by means of the screw, E, attached to D, and travelling through the standard, A B, the focus is adjusted.

Figs. 13, 15, 16, 17, 18, 19, 20, 23, 24, 25, 26, 27, 29, 30, and 31 were reproduced from the original Figs., in the works cited.

Fig. 14 is a woodcut from my sketch of the instrument.

Figs. 21, 22, and 28, were photographed on the wood-blocks from the original instruments, to ensure the accuracy of the drawings.

ELEMENTARY LECTURES.

ELECTRICITY.

By PROFESSOR GEORGE FORBES.

Lecture III.—Delivered April 17, 1886.

In my first two lectures I spoke about statical electricity, and about a current of electricity, and I mentioned that there was a time when it was absolutely necessary to prove that these two manifestations of electrical influence were identical. Now, there is no doubt about it. We know that statical electricity and dynamic electricity are identical, that there are not two kinds of electricity, but that the phenomena we studied on the occasion of the first lecture, and the phenomena we considered on the occasion of the second lecture, are really different manifestations of one identical force. The discharge of the Wimshurst machine is identical with the current from a battery, and the difference of electric potential at the terminals of a battery is of the same character as that at the two knobs of the Wimshurst machine. To day I am going to describe to you some of the principal phenomena of magnetism, and we shall find that here also we are dealing with simply another manifestation of this same electrical energy. The completest developments of the theory of magnetism in fact do actually go to prove that magnetism is simply due to a large number of small electrical currents, but about that we shall be able to say something more definite towards the close of the lecture. The facts in connection with magnetism which were known in days of old were very limited indeed. In fact, it seems remarkable that the discovery of the mariner's compass should have been delayed to so late a period in the world's history as it was. In various parts of the world occasionally pieces of mineral largely composed of iron are found, which have a definite line in their substance, which we call the magnetic axis, and which have this peculiar property, that when suspended by means of a thread, the line called the magnetic axis points roughly in a north and south direction if they are not disturbed by the presence of other pieces of iron in the neighbourhood. Here is a piece of lodestone which is marked at the two ends with a blue and red mark to mark the extremities of the axes, which lies along its length; then suspending it by a thread so that the axis is horizontal, we see that the direction of the axis of the lodestone remains in the magnetic meridian, that is to say, approximately, in a north and south direction. There is another property in connection with the lodestone, which is this, that two different pieces of lodestone influence each other, that they produce a movement of attraction or repulsion. Thus when I take one piece of lodestone, and bring it into the neighbourhood of another which is suspended, you see it immediately turning round, showing there is an influence between the pole I presented to it, and the pole of the suspended magnet. I have commenced these remarks with speaking about the lodestone, because that was really the earliest source of magnetism, but in our experiments which we may perform in the laboratory, instead of using a piece of natural lodestone, such as is found already magnetised, it is much more convenient and general to use a magnet artificially made, such as I have here, and which I can suspend upon a pivot. A magnet thus magnetised will set itself naturally in a north and south direction, and can be acted upon by another magnet brought near it so as to cause repulsion between the two north-seeking ends, or between the two south-seeking ends. You will now see that we likewise have an attraction between the north end of one magnet and the south end of another. This is generally expressed by saying that like magnetisms repel each other, and unlike magnetisms attract each other. The substance which is capable of being most powerfully magnetised is the metal iron. Nickel and cobalt possess the property to a less degree.

This action between a suspended magnet and another magnet is identically of the same nature as the action which takes place between the whole mass of the earth and a compass needle or suspended magnet, so as to cause it to lie in a fixed direction with respect to the earth. The suspended magnet tends to place itself in a north and south direction, the reason being that the whole of the earth acts in the same manner as this magnet which I hold in my hand does. When I hold the magnet, it tends to give a certain direction to the suspended magnet. The action of the earth is of the same nature, and it is due to the fact that the earth is magaetised as a whole – that there is a sufficient quantity of iron in this magnetic condition in the earth—that we have the most valuable property of the compass needle, viz., that it points north and south.

It was noticed in the 17th century that there is another action due to the earth's magnetism besides that which attracts the magnetic needle into the north and south position. It was noticed by Norman that if we take a bar of steel pivoted accurately at its centre of gravity so that it ought naturally to rest equally in every direction, then the end which points to the north will also incline downwards at a considerable angle, 70° in this country. Here I have such a needle which I place in the magnetic meridian fairly suspended on the pivot, and free to take up any position in the magnetic meridian. That compass needle, as you will notice, points at a very great angle—something like 70° to the horizon. This is spoken of as the dip of the compass needle. Gilbert, who was the father of the science of magnetism, wrote a great deal about this, and pointed out that the dip of the needle might be explained simply by supposing that the earth was acting as a magnet. Gilbert said if we have a magnet going through the earth, or only a short magnet at its centre, it will attract the suspended magnet, and the tendency will be for the magnet placed on the equator to rest horizontally. But if we were to bring the same needle up to, say, the latitude of Great Britain, then the end of it which was attracted by the pole of the magnet in the centre of the earth would point downwards. Therefore, we should have the compass needle when suspended at the centre of gravity not lying horizontally, but dipping down towards the horizon, and this will explain the dip of the needle, viz., that it is a directive action due to the magnetised portions of the earth. Gilbert had no more knowledge about dip than the fact that in these latitudes the dip was about 70°, but he saw, if his explanation was correct, that the dip would vary in different parts of the earth; that at the magnetic north pole of the earth the needle would dip vertically downwards, that at the equator it would be parallel to the horizon, and that the inclination would gradually change from the vertical to the horizontal as we pass from one of the poles to the equator. This was a prediction by Gilbert which was, as we know, fulfilled when observations were made in different parts of the earth by means of this dipping needle, which varies in inclination when taken to different parts of the earth. The spot near the North Pole, where it is perfectly vertical, has actually been visited by Arctic explorers, and the needle has been found to be vertical there.

When I was speaking to you about a statical electrified body, I told you there were two kinds of forces that came into play; one was a real true force, which caused a motion in a material body; the other was not what Newton would call a force, because it did not produce a motion in a body, but produced a motion of electrification. That kind of force we call electromotive force, and electromotive force produced a change in the arrangement of the electrical condition of bodies. We have an exactly similar thing in the case of magnetism. Whenever there is a magnet in the neighbourhood of any point of space, it is producing a force of this peculiar kind, not only a force that will produce motion in a body, but a force tending to produce a re-arrangement of the magnetic condition. An electric current in a conductor also acts in this way on space in its vicinity. We shall see a little more clearly presently how this magnetic induction is created; but as we study the question of magnetism more fully we shall find that all the magnetic phenomena are produced by the action of forces which, besides having the power of attracting and repelling magnetic poles, are also able to rearrange the condition of magnetism in iron bodies, and those forces are trying to change the condition of magnetism in those iron bodies. If the bodies offer sufficiently small resistance, then the change in the condition of magnetism can take place, and we have magnetic induction; if they offer a large resistance, the change cannot take place to a great degree. The analogy is most remarkable between this, which we might call magneto-motive force, and what we have spoken of as electromotive force. The small resistance which iron, nickel, and cobalt oppose to the re-arrangement of the magnetic state, and the large magnetic resistance of all other materials, is exactly analogous to the resistance which is offered by different materials, either conductors or insulators, to the re-arrangement of the electrical condition when a body is subjected to the electromotive force. But there is no material which is anything approaching a perfect magnetic insulator. I will carry the analogy still further by reminding you of the remarks which I made in my lecture on what is called electric potential. I said there was a difference of electric potential between any two bodies which were electrified, one positively and the other negatively; so also I say there is a difference of magnetic potential between the two ends of this magnet. I said that we meant by a difference of potential that work was done in carrying something from one point to another. There is a difference of gravity potential between the floor and the table, because work is done in lifting a mass from the floor to the top of the table. There is also a difference in magnetic potential between the two ends of the magnet, because work must be done in carrying this magnetic pole from the one to the other, it being attracted by the first one, and repelled by the second. The condition of re-arrangement of the magnetic state, owing to the existence of a magnetising force, is called magnetic induction, and the magnetic induction which results depends partly upon the direction in which the magnetising force is acting, and partly on the shape of the body which is being acted upon. Iron is the body which most freely permits the action of this magnetising force. In other words, we should say that iron offers less resistance than any other material to the induction due to a magnetising force. The softer the iron, the less is its magnetic resistance, and hard steel has much more resistance than wrought iron.

I have here a compass needle suspended, which will perhaps enable me to illustrate some of the phenomena of induction by throwing the image of it on the screen. The compass needle is now suspended in a certain direction. I wish to show you the production of induction in a piece of iron by subjecting it to magnetising force. The magnetising force which I shall employ is the earth's magnetism. We know, from what has already been said, that the earth's magnetism acts in a north and south plane, and moreover that it acts far more up and down than it does horizontally. Thus the direction of magnetism is something of the direction in which I am holding this bar. At present, therefore, the bar is in a position subject to the action of the magnetising force; that is due to the earth which is trying to pull the north end downwards, and trying to drive away the south magnetism at the other end. If this were a magnet freely suspended, as the dipping needle was, it would set itself in this direction with north end downwards. But it is not a magnet, and I say the magnetising force of the earth produces a re-arrangement of the magnetism of this bar. I will try and show you that that is the case. If that is the case, then the earth is creating a north pole at the lower end of the bar, and a south pole at the upper end, as you see by the motions of the needle, and it will remain so, even though I reverse the iron bar, still you see the north pole points to the ground, and the south pole points upwards. I hope I shall be able to show you that there is really a magnetising force acting on this iron, and to prove it to you by the fact that this selfsame end is a north pole when it is pointing downwards, and a south pole when it is pointing upwards. I will bring the upper end first towards the needle. You see the direction in which the needle tends to go in a horizontal direction as shown on the screen. The opposite end of the iron will certainly be found to be magnetised in the opposite direction. Now the remarkable thing I wish to show you is this, that when I turn the iron round I shall reverse the polarity of the iron bar. I now present that pole which deflected the needle vertically before and it deflects it horizontally, and the other end deflects it into a vertical position instead of a horizontal.

Now I wish to show you some facts which enable us to get a very fair notion of the ultimate nature of a magnet. I have told you that in the laboratory it is not very convenient or customary to use pieces of lodestone as magnets, but that we use little magnets which have been artificially made. We can convert pieces of common steel into magnets in a variety of ways. One way is by making use of the lodestone itself and drawing one of the poles over the piece of steel. On drawing one pole of the lodestone over the piece of steel always in the same direction, the steel is converted into a magnet. Here is a piece of steel tape; first I will show you that it is not sensibly a magnet, that it does not seriously influence the compass needle. Now I lay down this piece of steel tape and draw a pole of the magnet over it from one end to the other of the tape in one direction. By this means I am producing a magnetising force, and that is an action very much the same as was produced by the earth's magnetism on the soft iron. The only difference is that this steel is not like soft iron, and when it is magnetised it does not lose its magnetism easily, therefore, it is not easily reversed as you saw in the iron bar. I have now stroked this over several times with one of the poles of this magnet, and on bringing it into the neighbourhood of the compass needle, the latter is violently deflected, thus showing that this steel tape has been converted into a magnet; one end attracts the needle into the horizontal position, and the other end repels it. Now the whole of this magnetism is resident at the two ends, and it might be thought that in the first place we have north magnetism at one end of the steel, and south magnetism at the other end. If that were so, you would think that upon breaking this you ought to have the whole of the north magnetism at one end, and the whole of the south magnetism at the other. I will try that experiment and see what happens. I have broken the steel into two portions. I bring one end towards the needle, and it is moved in one direction, and now I bring the other end towards the needle, and it is moved in the opposite direction. The same with the other fragment. The two ends have opposite polarity when I have broken the fragment into two, and I might go on breaking it again, and still there would be the two poles in each fragment. I might imagine it to be broken smaller and smaller, until I had reached an ultimate molecule, but I should always have the two poles north and south, that is to say, carrying it to the extreme limit, the actual molecule of iron is magnetised, and has magnetic polarity, one end of the molecule being north, and the other end of the molecule being south. This is a theory which has been developed by various persons, and is now pretty generally accepted. The theory as generally accepted now-a-days is that the molecules are all magnetic with a north end and south end, and that in every piece of iron the molecules are of that nature; but that when we subject the iron to a magnetising force, then we arrange the direction of those molecules so as to be all parallel to one another, and in the same direction. It is perfectly clear that if we had a lot of little magnets all arranged in the same direction and parallel to each other, with their north ends pointing all in the same direction, and their south ends pointing in the other direction, then the whole group of those magnets will act as one large magnet does, they would attract the compass needle in exactly the same way that we find a magnet attract the compass needle. Moreover we know that if a mass of iron were so constituted, made up of molecules like that, and if it were subjected to a magnetising force, and if those molecules were free to move, that they would tend to arrange themselves in the direction of the magnetising force, and that they would make the mass of metal into a magnet just as you saw the iron bar did when subjected to the inductive action of the earth's magnetism. This is the theory of magnetism which is most generally accepted.

I have shown you one way of converting iron into a magnet, but we have another and much more potent manner of doing so, and that is by the aid of the electric current, and with the discovery of this power in the electric current to convert iron into a magnet, a field was opened for an enormous number of practical applications of electricity and magnetism. I will show you electro-magnets of two very different shapes, and show the effects which can be drawn from them. The first one is suspended up here, and simply consists of two flat discs of iron, with a circular groove between them, in which groove is a coil of insulated copper wire. I shall pass an electric current through the wire, and now it has become a powerful magnet able to support a very heavy weight. When we look at the small size of the magnet, weighing about three ounces, and the considerable weight supported, over 100 pounds, it is most striking. This is for its weight the most powerful electro-magnet I have seen, the proportions being specially designed for that purpose.

Here is another electric magnet of a different form. This is a horseshoe of iron, round which are coils of wire, At the present moment it has no influence whatever; it is not magnetised at all; but as soon as an electric current is sent through the coils, you see it requires considerable force to lift off the iron armature lying on one of the poles. Now I will connect the two poles by means of the iron armature or keeper, and then the force with which it attracts is something enormous. Not only can I lift the magnet bodily up by this keeper, but it is impossible to remove the keeper from it by any force which my muscles can exert. When I first had this magnet some fourteen years ago, I was showing the experiment to some students, and I told my audience that as soon as the current ceased to circulate in this wire the magnetism would disappear, but to my astonishment on trying it I found that it did not disappear at all. There is no current passing through the wire at present, but still it attracts the keeper, and I cannot pull the keeper off by a direct pull. If, however, I slide that iron keeper off, the magnetism absolutely disappears. As a matter of fact this piece of iron is so remarkably soft that the magnetic induction which is taking place continuously through the iron mass retains this arrangement actually after the magnetising force has been removed. I once made a special kind of dynamo machine, and after the field magnets, which were of the softest iron, were magnetised, they retained the magnetism even if the magnetising current were stopped, and continued to do so. I will show you an experiment which suffices to show that when the current disappears the magnetism does disappear. Here we let the keeper only touch one of the two poles of the magnet, and as soon as the current stops the magnetism stops too. But when I have the iron formed in a complete ring so that all the molecules are end to end all the way round, it retains its strength even after the current has ceased. There is another interesting experiment, in which instead of the solid keeper I use a mass of horseshoe nails which form a bridge from one pole of the magnet to the other, and which present a curious appearance of rigidity, but directly the current is broken they fall apart.

Faraday, when he was engaged in his brilliant researches on magnetism, was accustomed to study the nature of induction, and the direction of magnetic induction in space, by means of iron filings. I have here a small horseshoe magnet fastened under a horizontal sheet of glass, which I shall project on the screen. I now dust the glass over with iron filings, and you will see the direction in which they lie after I shake the glass. Each little piece of iron filing is converted, temporarily, by the force of the magnet into a magnet itself, and it settles itself in the direction in which the inducing force of the magnet is acting at that point of space. You notice these beautiful curves connecting the poles, which come out more clearly when I tap the glass gently, so as to allow the filings to arrange themselves. In the first place you see there is always a tendency for the lines of induction to go from the north pole to the south pole. At every point the direction of the filings indicates the direction in which induction is taking place at that particular spot. I shall not enter much into the question of these lines of force to-day, but Faraday thought a great deal about them, and the conception he used has been very generally adopted, and is a very material aid to the understanding of some of the more difficult problems of electricity which we shall be coming to in the succeeding lectures. If we suppose that the magnet itself consists of little pieces of iron, with north and south polarity going all the way through the magnet, from one pole to the other, then these iron filings continue the chain, and we have a continuous line of force going right through the magnet from one pole to the other and then through space. Some of them go right through to the end, and then come back, others only go partially through the magnet, and come back across the air-space. But by a study of the direction of these lines of force we are able to get a great insight not only into the theory of magnetism, but into magneto-electric phenomena, which we shall be examining presently.

I will now throw on the screen another illustration of the same kind in which I have unlike poles facing each other, and you will see the direction which the line of force will take when we spread the iron filings there. The general tendency is to cause the lines of force to cross from the north pole to the south pole; not only in a direction straight across, but also in every direction in space. They may take all sorts of different directions, but they are always passing from one pole to the other. The lines of force then go right through the iron; and it is very important in the conception of lines of force to retain that notion that these lines are continued through the iron, and are closed curves having no ends, and that this arrangement of molecules of which I have spoken is really existing in the iron. This is a very beautiful means of studying the phenomena of induction, and the condition of the magnetic field in the neighbourhood of magnets which was very largely used by Faraday.

I have been speaking about these ultimate small particles of iron as being magnetic in themselves, and I should mention here a further theory or hypothesis which has been advanced to account for the existence of magnetism in these ultimate molecules. That is the theory which the great French philosopher Ampère proposed. He suggested that a molecule of iron is nothing more nor less than a circular current of electricity. If a current of electricity could be created in a circular piece of metal, and if that metal offered no resistance to the current passing, that current of electricity would go on for ever; and what Ampère suggested really amounted to this, that a molecule of iron is a perfect conductor of electricity, in which an electric current had been at one time or other established when it was created, and consequently the electric currents are going on, continually circulating in those molecules. I can show you this much, that if we had a circular current of electricity, the action would be such as Ampère described. Here I have a coil of wire, the two ends of which are attached, one to a piece of copper, and the other to a piece of zinc. I shall dip this coil into a vessel containing dilute acid, the vessel being floated in this glass dish. Now the coil of wire has a current of electricity in it, because the dissimilar metals are dipping in a solution of acid and water; and we find that that coil takes up a position so that its axis is in the direction of the magnetic meridian, so long as there is a current of electricity passing through it. I can show you that the action of the magnet upon it is similar to the action of the magnet upon another freely suspended magnet. I can do that by means of this bar magnet; I can attract or repel that coil according to the pole of the magnet I employ, and according to the side of the coil at which I approach that pole. You see now it turns round and presents the other face towards me. I can attract the whole thing bodily towards the sides of the vessel. The other pole will attract the other side of the coil bodily right across the vessel. Thus whatever magnetising force I may have in the space occupied by this floating coil, the coil will always tend to set itself with its axis parallel to the magnetising force exactly in the same way as a freely suspended compass needle would do. Finally, I may force the coil to pass over the bar of iron and to run along the whole length of it, showing the different series of actions which are exercised between the magnetic bar and the circular coil which has a current of electricity passing through it. This is the typical magnetic molecule which Ampère suggested as being the true molecule of iron, and if we can conceive of a molecule having a current of electricity revolving round it like that, the whole of the actions of magnetism would take place just as we know them to do. This is what I meant when I said that we should find that magnetism is also another manifestation of the same electricity which we were examining in our last two lectures.

It was shown first by Joule that when we magnetise an iron bar its length is increased. It has been supposed by some that that is due to the fact of these magnetic molecules of iron being really of greater size in the direction of the axis than across, so that when a magnetising force acts on them so as to put their lengths all in the same direction, they naturally take up more space lengthways than if they were all mixed up in different directions. Whether that is the true explanation or not I should not like to say. The experiment that Joule showed proved conclusively that iron does expand when it is magnetised. It is a very important experiment, which I believe is destined to give us a great deal of information in the future as to the nature of magnetism. It is an experiment about which we do not know anything yet; but a great deal has been done in the course of the last year or two, and the astonishing fact has been discovered by Mr. Shelford Bidwell, that not only does iron expand when we put it into a magnetic field of a certain strength, but that if we increase the strength of that field, and the power of induction acting on the iron, to a considerable extent, we diminish the action; that is to say, that as we go on increasing the magnetising force we first get expansion, but finally an absolute contraction, and the contraction is very much greater than the expansion which had been investigated by Joule. I am fortunately able to show you this experiment, which Mr. Bidwell has been kind enough to set up for us, and he will kindly throw upon the screen an image of it by the limelight. I will indicate a part of the arrangement. Here is a piece of iron rod that is fixed at the bottom but presses on a lever upwards. The end of the long arm of that lever acts on a mirror attached on a pivot, so that if the piece of iron lengthens it will give motion to the mirror, and the spot of light reflected from it will be seen to change its position. If the iron were to grow shorter the spot of light would be seen to rise up on the scale. I will first commence with comparatively feeble magnetising power. The black line on the scale is a fixed wire reflected by a mirror, and when I pass a current round the iron wire, so as to magnetise it with a comparatively feeble current, we see a descent of that line, indicating that the iron has expanded in length; there is a motion of about an inch and a half or so. I will now ask Mr. Bidwell to put in an extra strength of current, and you notice the very large contraction indeed indicated by the rising of the spot of light. This shows the contraction of the iron when we use it with sufficiently high magnetising power. This was not noticed by Joule, because he did not use a strong enough current. Finally, as we have this experiment arranged, I will show you the contraction produced in nickel, which will indicate to you that nickel, one of the other magnetic metals, also contracts. I might mention that in all these experiments the total movement is something extremely small—something like one-millionth of an inch to a hundred thousandth, and as the piece of wire is only three or four inches long, the enlargement which we are obliged to have to make it evident is very great indeed. But this mechanical arrangement which Mr. Bidwell has introduced is very satisfactory. On introducing, now, the nickel, we find a rise of several inches when contact is made. The feebler power that gave expansion with iron, gives a sensible contraction, and on increasing the magnetisation, you see that the contraction is very great.

Miscellaneous.

CANAL NAVIGATION.

The following particulars respecting canals as a means of transport are taken from an article in the *Engineer*:—

There are now in the United Kingdom 3,931 miles of canal navigation, of which 927 miles belong to public trusts, 1,445 miles to independent companies, 1,333 miles are guaranteed and owned by railway companies, 188½ miles are derelict, and 37 miles belong to owners of whom nothing appears to be known. It will thus be seen that 34 per cent. of all the canal mileage in the country is in the hands of the railway companies. The chief among the canal-owning railways is the London and North-Western, which has eight different canals, having a total length of 488½ miles. Among these, the two principal, alike in respect of their length, and the districts which they traverse, are the Birmingham canals, with a total of 169 miles, and the Shropshire Union Canal, with a length of 203 miles. These canals pass through very important districts, and should, if they were allowed fair play, prove a very formidable rival to the railway system of which they may be said to form a part. The first will admit of 72 ft. by 7 ft., and the second is adapted for vessels of 80 ft. by 15 ft. The Midland Railway possesses only the Ashby-de-la-Zouche and the Oakham canals, the latter of which has been converted into a railway. The Great Western Railway owns 257½ miles of canals, the two principal of which are the Kennet and Avon, 85 miles in length, and the Monmouthshire, Brecon, and Abergavenny, 54 miles in length. The former canal is distinguished for the large size of craft that it can provide for, occupying in this respect the fourth position among the canals of England, as the following figures show:—

The Severn Trust Canal will admit craft	270 ft. by 35 ft.
The Aire and Calder ,, ,, ,,	212 ft. by 22 ft.
The Gloucester and Birmingham ,,	163 ft. by 29 ft.
The Kennet and Avon ,, ,, ,,	120 ft. by 18 ft.

The Great Western Railway Company has converted into a railway the Hereford and Gloucester Canal, thirty-four miles in length, which probably did not traverse a district of the first industrial importance; but all the same, the alternative route for heavy traffic was calculated to be a real public benefit. Several important canals are owned by the Manchester, Sheffield, and Lincolnshire Railway, including the Chesterfield, forty-six miles in length, and the Dunn Navigations, thirty-nine miles long. The total length of the canals owned by this company is 180½ miles, and 104½ miles more are owned by the Great Northern Railway Company, the principal two being the Grantham, 33½ miles, and the Witham Navigation, 31 miles long. Canals of minor extent are also owned by the Lancashire and Yorkshire, the North-Eastern, the North Staffordshire, and the Great Eastern Railway Companies. Most of the canals so owned are scarcely worked at all, no provision being made, as a general rule, for allowing the public the choice of such an alternate method of transport. It is, of course, quite a different matter with canals owned by public trusts and independent companies. These unitedly own or control 2,372 miles of canal navigation in England and Wales, which is 1,039 miles more than the extent of navigation owned by the railway companies. The fact is, that few industrial centres are without canals that may be resorted to for, at any rate, local traffic, while many give access to the larger markets of the country. In Lancashire, for example, there is, among canals of importance, the Duke of Bridgwater's, the Irwell Navigation, the Rochdale, and the Leeds and Liverpool; in Staffordshire and Worcestershire there is the Birmingham, the Stourbridge, the Warwick and Birmingham, and the Staffordshire and Worcestershire canals; in Yorkshire there is the Aire and Calder, the Leeds and Liverpool, and the Ouse river; in Leicestershire, the Leicester, and the Leicester and Northampton canals; in Cheshire, the River Weaver, and the Droitwich canals; in Wales, the Aberdare and Glamorganshire canals; in Gloucestershire, the Avon, the Wye, and several smaller canals, not to speak of the Severn river; and so with other counties and districts. But it happens in only very few cases—as in that of the Leeds and Liverpool Canal—that these canals, all of which are controlled independently of railways, afford through communication from one important centre to another. They do not, as do the railways, form great trunk lines, by means of which goods can be transported direct from any one part of the kingdom to any other; and they also labour under the serious disadvantage, in practical operation, of lack of uniformity of dimensions, rates, and general control. Some of them will allow of vessels over 200 ft. long, while others will only pass craft of 50 ft. to 55 ft. It would be possible to remedy this condition of things, if the canals were not under so many separate and conflicting jurisdictions, and especially if the railway canals were made as free as all the others. As it is, about 120 miles of canal navigation have been converted into railways, and 188 miles have become derelict or abandoned, presumably in consequence of their failure to remunerate their owners for the cost of maintenance. Most of the existing water-ways are in a more or less neglected state.

While Great Britain has been neglecting her internal water-ways, and while our traders have been content to depend upon railway transport almost exclusively, the French and some other nations of Continental Europe have been spending large sums of money in endeavouring to establish a complete system of canal transport between the chief industrial and commercial centres. A Commission of the French Chamber of Deputies reported in 1879 that it was "impossible to fulfil the requirements of commerce and industry without the service both of railways and canals," and hence they recommended the completion of the network of canal water-ways in France by the expenditure of 11¾ millions sterling on the improvement of existing canals, and of 16½ millions on the construction of new ones, making a total of about 28½ millions sterling. In favour of this project, the Commission stated that while coal could not be carried on railways for less than 0·5d. to to 0·6d. per ton per mile, it could be transported by canal at less than one-half the lowest of these rates. This has been much the experience of the canal system of Belgium, which has in consequence been carefully cultivated and largely extended. On the other hand, however, it must be said that there is certainly not much encouragement to be drawn by those who desire to see the canal navagation of the past restored to its prestine utility as a means of transport from the annals of the canal system of the United States. In that country there were in 1880—the most recent year for which returns are at command—the total of 4,468 miles of canals, or about 136 miles more than the total canal mileage of England and Wales. But of these 4,468 miles, no less than 1,953 miles had been altogether abandoned, and it was reported that a large part of the remaining 2,515 miles was not paying expenses. In the New England States all the canals had been abandoned. In New York State, 357 miles of canals, the construction of which had cost over 10¼ millions of dols., had been abandoned, as was also 447 miles in Pennsylvania, constructed at a cost of 12¾ millions of dols.; 205 miles in Ohio, constructed at a cost of 3 millions of dols.; and 379 miles in Indiana, costing 6¼ millions of dols. so recently as 1851. The total cost of the canals of the United States has been returned officially at 214 millions of dols., or about 53 millions sterling. The average cost per mile of canal built has been 48,000 dols., or about £9,600, against an estimated average of £6,560 for the canals in the United Kingdom, and an average of £6,229 per mile for the French canals.

The two most important American canals, the Erie and the Champlain, are both in the State of New York. The former canal was constructed for the purpose of uniting the waters of Lake Erie and the Hudson. The total length of the canal, with its branches and feeders, is 365 miles, and the total cost was 51,609,000 dols., or upwards of £141,000 per mile. The width of the canal is 70 ft. at the surface, and 52½ ft. at the bottom, the depth being 7 ft. There are 72 locks, each 110 ft. in length, by 18 ft. in width, and having a rise and fall of 656 ft. The total freight traffic on the Erie Canal, in 1880, was 4,608,651 tons; the gross income 1,120,691 dols.; and the net income, 442,567 dols.—which was only equal to paying about 1 per cent. on the capital cost of construction. The total expenditure incurred on behalf of the canal for the year in question, including cost of working, was 678,124 dols., or 60 per cent. of the gross income. In the case of the Champlain Canal the results are even less satisfactory, the amount of freight moved in 1880 having been 1,200,000 tons; the gross income, 51,267 dols.; and the expenditure 136,520 dols.; leaving a deficiency of 85,253 dols.

Now compare these figures with those that refer to the chief competing route—the New York Central Railroad. In 1868, the total traffic carried on that line was 1,846,000 tons, and the average ton-mile rate was 2·743 cents, or more than three times the amount of the average canal rate for the same year. Yet, in spite of this enormous difference, the railway traffic went on increasing until, in 1873, it amounted to 5,522,000 tons, being an increase of 3,676,000 tons, or about 200 per cent. on the quantity carried in 1868, notwithstanding the enormous difference in the cost of transport as against the railroad already referred to. In 1873 the average ton-mile rate on the New York Central had been reduced to 1·573 cents, a reduction of 1·170 cents, or about 43 per cent. on the average ton-mile rate of 1868. But even at the reduced rate, the railway was still charging ·686 cents, or about 77 per cent. more than the canals. It might be thought that this difference would tend to militate against the progress of the railway in the comparatively depressed times that followed. The official figures show that between 1873 and 1883 the traffic on the New York Central Railway had just about doubled, while on the canals of the same State there was a very considerable decline. The movement may be even more strikingly illustrated if the average rates by canal and lake and by railroad alongside the total grain and flour traffic received at New York for the period 1878-1884, are grouped in one Table as set forth in the official report on the foreign commerce of the United States for 1884:—

GRAIN TRAFFIC BY CANAL AND RAILWAY BETWEEN CHICAGO AND NEW YORK, AND AVERAGE RATES PER BUSHEL.

Year.	Grain and Flour receipts at New York.		Average rates per bushel.	
	By canal and river. (1 = 1000 bushels.)	By rail. (1 = 1000 bushels.)	By canal.	By rail.
			Cents.	Cents.
1878	63,905	85,050	9·15	17·7
1879	57,044	101,116	11·60	17·3
1880	69,440	95,414	12·27	19·7
1881	38,192	98,574	8·19	14·4
1882	34,631	81,224	7·89	14·6
1883	44,946	81,636	8·40	16·5
1884	—	—	6·60	13·0

The greatest advantage possessed by canals next to that of their lower first cost is the much lower expenditure in working and maintenance than belong to railways. Mr. Conder has calculated that out of every £200 paid for an equal tonnage transported an equal distance, the detailed costs are:—

Item	By railway.	By canal.
	£	£
Maintenance of way	13	0·
Maintenance of works	7	2·3
Repairs of rolling stock	19	6
Traction	16	8
Traffic expenses	30	6
General charges	15	15
Interest on capital	100	33·3
Total	£200	£70·6

On these and other data of a cognate character it has been calculated that while the cost of an equal amount of traffic on the railways and canals of the United Kingdom would be 1·21d. per ton per mile in the case of the former, it would only be 0·37d. per ton per mile in that of the latter. In other words, canal transport is little more than a fourth that of railway transport for the same volume of trade. If the substantial accuracy of this estimate were to be assumed, it would seem to follow that if canals are made to take the place of railways as regards mineral traffic generally, the cost of transporting such traffic, which now amounts to about £16,000,000 sterling per annum, might be reduced to little more than £4,000,000, which would leave a balance of about £12,000,000, now paid for railway transport, either to be disposed of in favour of the general public, as consumers, or to help to provide that margin of profit for coalowners and ironmasters to which they have now for some years been strangers.

PRODUCTION OF NITRATE OF SODA IN CHILI.

Extensive deposits of nitrate of soda exist at Antofagasta, Taltal, and other places in the desert of Atacama, but the chief centre of production is the newly-acquired province of Tarapaca, which is described as one immense bed of this valuable salt. At the present time the nitrate business appears to be passing through a series of crises which is the result of two distinct causes. A commission appointed by the United States Government to inquire into the industrial and commercial condition of the Central and South American States, writing on the subject of the nitrate deposits, says that, in 1875, the Peruvian Government appropriated the nitrate deposits of Tarapaca and compelled the proprietors of works to hold them under leases from the Peruvian Government, and to produce nitrate subject to the payment of a royalty, but the production was limited to a certain specified quantity per annum. The object of the Peruvian Government in appropriating the nitrate deposits, and in limiting the production, was to prevent nitrate competing with guano as a fertiliser. When Chili took possession of Tarapaca the works belonging to the Peruvian Government were sold, those which had been seized but not paid for, were restored to their rightful owners, and the production of nitrate was declared to be free. A considerable impetus was thus given to the production which was already in excess of the demand when, rather more than a year ago, a sudden collapse in a large consuming market brought about a crisis in the nitrate business. About three years ago, the beet growers commenced to use nitrate as a fertiliser. The roots attained an enormous size, and the quantity produced per acre far exceeded that obtained by any other fertiliser. Experience, however, soon demonstrated that, although the beet roots attained an unprecedented size under the influence of nitrate as a compost, it was at the expense of the saccharine matter contained in the root, and it was also discovered that the salt had a deleterious effect upon the sugar in the act of granulation, and even upon the sugar itself. The result of this discovery has been the refusal of the best sugar producers to purchase roots to which nitrate had been applied. To meet this altered condition of affairs the nitrate producers combined not to produce more than 10,000,000 quintals per annum, and with the object of finding a new outlet for their production, the owners of nitrate works agreed to offer a prize of £1,000 to the discoverer of a new use for nitrate; and they also purposed distributing among agricultural societies, institutes, and schools, 500 tons of salt for experimental purposes. A considerable quantity of iodine, for which practically there is an unlimited market, is obtained from nitrate, but as it is a residual product, the quantity obtained obeys the laws of production of nitrate. The iodine is held in solution in the water in which the nitrate earth is boiled, and washed, and the reagent used is sulphuric acid. The total value of the nitrate of soda exported in 1883 amounted to £6,409,000, of which the United Kingdom took £5,878,000, and the United States £168,000. The total value of the iodine exported in 1883 was £597,000, of which £90,000 went to the United States, and £355,000 to the United Kingdom.

Obituary.

SAMUEL MORLEY.—Mr. Morley died at his London residence on Sunday, 5th inst., after a long-continued illness, which prevented him from appearing in public. He was born at Wells-street, Hackney, in 1809, and early in life took a prominent position in the business of his father. In July, 1865, he commenced his political career by becoming a candidate for the representation of Nottingham. He wns returned, but unseated on petition in the following May. In 1868, he was elected member for Bristol, and he continued to represent that city until 1885, when he declined to come forward again at the general election of that year. Mr. Morley was a deputy-lieutenant and magistrate for Middlesex and Kent. His many deeds of philanthropy, performed during a long life, are well known, and he is said to have spent between £20,000 and £30,000 a year in religious and benevolent works. Mr. Morley was elected a member of the Society of Arts in 1854, and took a prominent part in the promotion of technical education. In 1875, on the formation of the National Training School for Music, Mr. Morley founded two scholarships of £80 for five years in connection with Nottingham and Bristol. He was a member of the Executive Committee of the City and Guilds of London Institute.

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CANTOR LECTURES.

THE MICROSCOPE.

By John Mayall, Jun.

Lecture III.—Delivered December 7, 1885.

Early Italian Microscopes.—In an Italian work, entitled "Nvove inventioni di tvbi ottici," which appears to have been a communication to the "Accademia Fisico-matematica," of Rome, in the year 1686, signed by "Carlo di Napoli" (but which was probably written by Ciampini, the editor of the "Giornale de Letterati," *vide* Langenmantel's notes on Tortoni's microscope in "Miscell. curiosa," 2nd Decade, 7th year, 1689, p. 444), a Plate is given of a number of curious forms of microscopes which are reproduced in Fig. 32 (p. 1032).

The microscope, shown in *Fig.* 1, is similar to the one we noted from Sturm's "Collegium curiosum." *Fig.* 2 is a sort of goblet with a lens on the top. *Fig.* 3 is not glazed at the sides, so that the objects could be readily changed. *Fig.* 4 seems to me an older form than Cuno's simple microscope, which we have examined, and may be the original design that suggested Cuno's which was improved upon by Musschenbroek, Wilson, Lieberkühn, and others, down almost to our own time; it has generally been termed "The Opaque Microscope." The rod, B, carrying the lens-holder, A, slides and turns in the sockets, D D, and the forceps, G H, fit similarly in E E; D D and E E are pivoted at F. The forceps are sprung open by pressure of the screw I. *Fig.* 5 embodies quite original points (so far as I know); the objects are fixed on the edge of the vertical disc, G, which rotates under the lens in the centre of the disc, D, and different portions of the objects can be brought in the optic axis by the screw-action of the peg, H; C is a spring carrying the lens-holder, D, and by means of the cord, E, winding on the peg, F, the lens-holder was drawn down to the proper focus, or by the reverse action it was raised by the spring, C. *Fig.* 6 is of special interest from the fact that it is stated to have been designed by "Hombergh, Gentiluomo Indiano"—Homberg the well-known member of the "Académie des Sciences," of Paris, and whose "Éloge" was written by Fontenelle. The eye-piece was of peculiar design, the field-lens being mounted at the upper end of an inner tube over which slid an outer tube having the eye-lens at the top; the separation of the lenses could thus be varied. The body was of brass, on which a screw-thread was cut on a length of about two inches, and the focussing was effected by rotating the body in the brass screw-socket, A B; the extended bearing of the screw (which had a rather fine thread) made the movement far more accurate and steady than was usual in microscopes of that date. *Fig.* 7 shows the same model, said to be improved by mounting the body to screw in a ring on an arm on a pillar, instead of the tripod. *Fig.* 8 was designed by "Carlo Antonio Tortoni." For viewing transparent objects, this microscope was to be directed to the sky, the light passing through the aperture, E, in the base-plate. This microscope was furnished with a field-lens, otherwise its similarity to the Campani instrument, we have examined, is manifest. Another somewhat similar microscope, by Tortoni, was communicated to the "Miscell. curiosa" (cited above) by Langenmantel. *Figs.* 9 and 10 are attributed to "Marco Antonio Cellio;" the lower tube, in *Fig.* 10, screws in the socket at A for focussing; the upper is a draw-tube; a field-lens is applied; the object-slide passes through a slot in the base, and is held by springs (shown at E E in the circular figure on the right). Here, again, the modifications from Campani's design (except, of course, the presence of the field-lens) are but slight, as, indeed, noted by the author of the paper. *Fig.* 11 is said to be the "smallest of all the microscopes;" the sides were of wood, and the multiple object-disc (No. 2) was fitted to rotate between them, the portions, N M, projecting at the edges for convenience of turning. The lenses are said to have been made of "crystal," of about the size "of a small grain of millet;" the magnifying power was therefore high; they were mounted in discs as at S (No. 3), and a diaphragm Q was pivoted at R on the other side (No. 1) to regulate the light. A focussing screw (No. 4) was applied at the upper end between the sides at I (No. 3), and the milled edge disc, L, projected slightly beyond the top for the action of the finger.

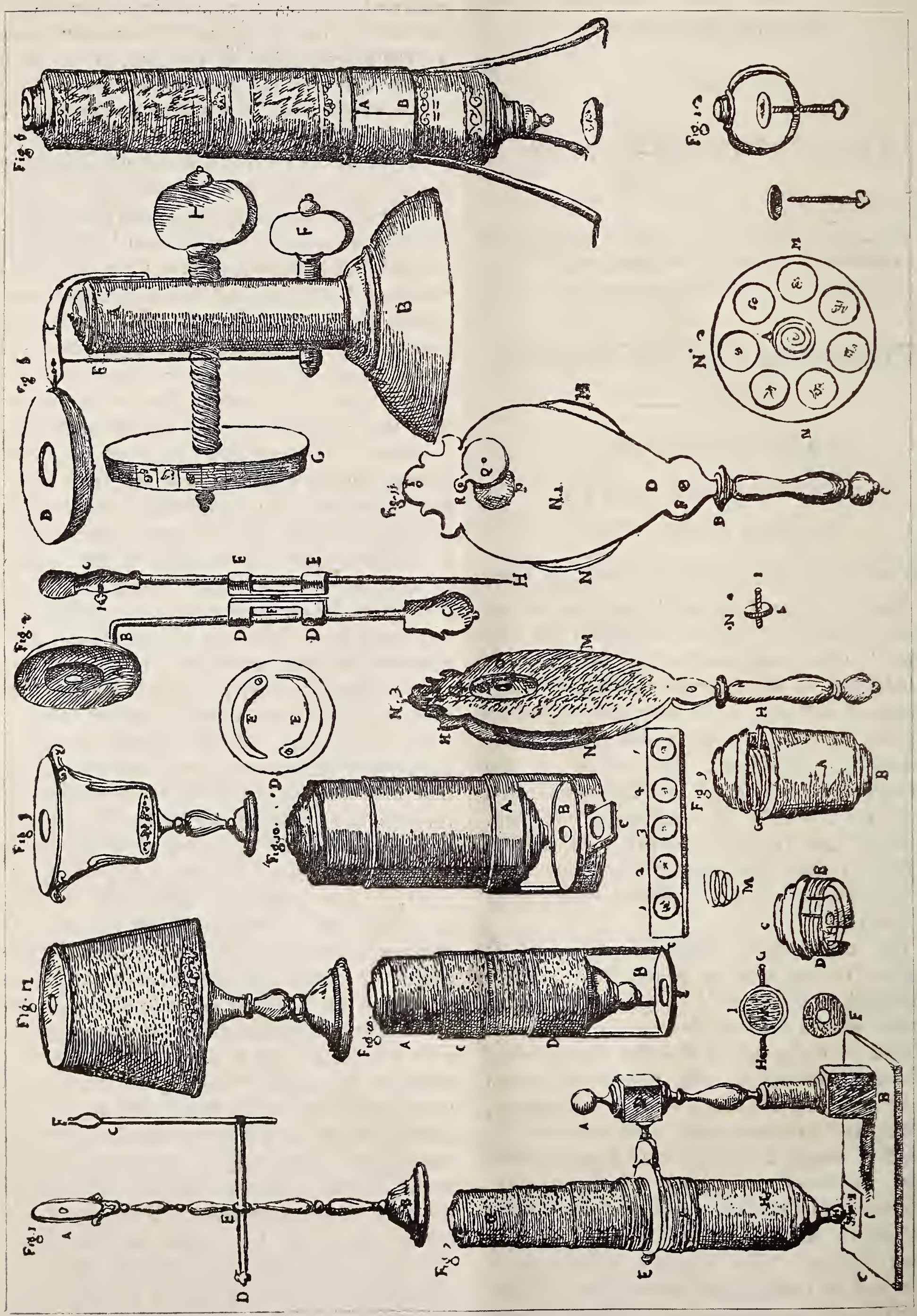
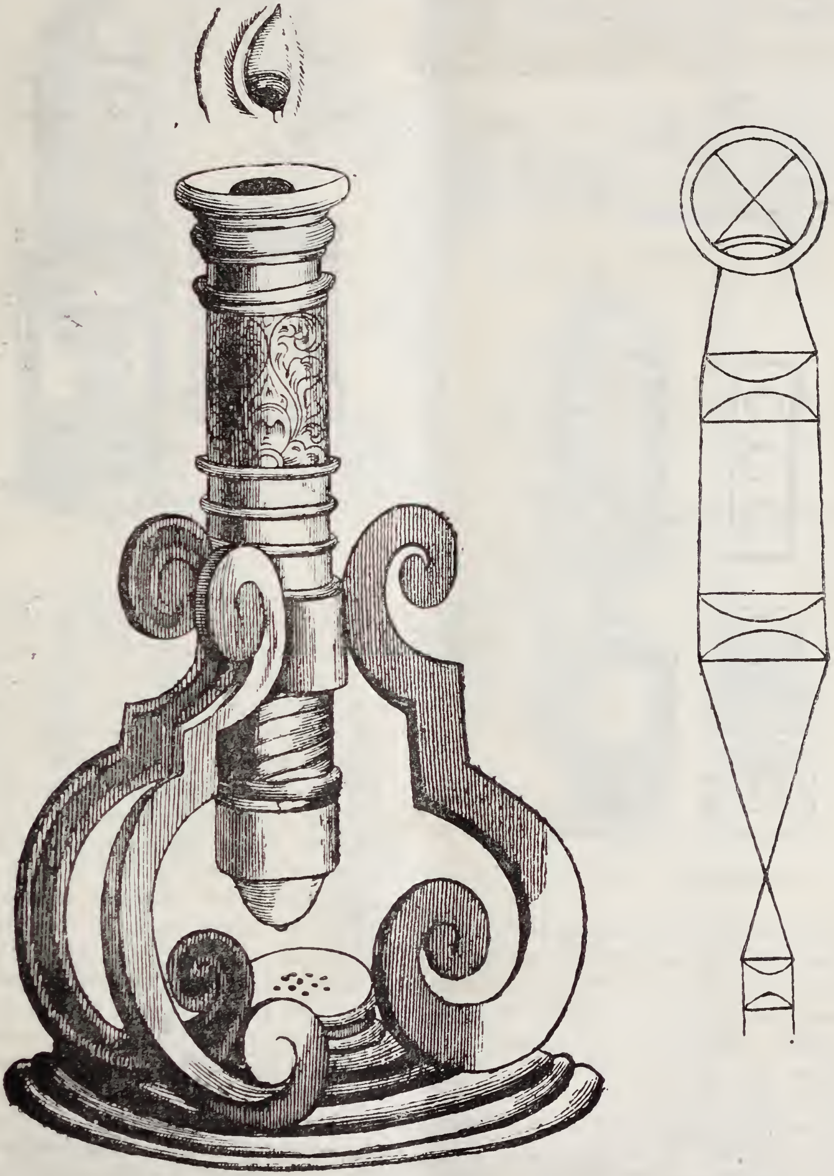


FIG. 32.—EARLY ITALIAN MICROSCOPES (1686).

Fig. 12 is said to have been devised by Tortoni; the lens formed the signet of the ring, and on the opposite side of the ring a hole was made, through which a short screw-rod travelled, carrying a small object-plate to the focus.

Grindl's Compound Microscope. — In Grindl's "Micrographia nova" (Norimb., 1687, 4to), p. 7, we find the microscope whence my Fig. 33 is copied. The optical construction is stated by Zahn ("Oculus artificialis," 1685, Fundam., III., p. 234) to have been communicated to him by Grindl in December, 1685.

Fig. 33.



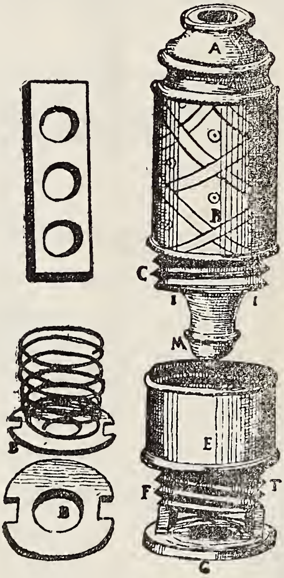
Grindl's Compound Microscope (1687).

I have already noted that Divini combined two plano-convex lenses, with their convex surfaces facing, to form an eye-piece, with which he claimed that objects were seen less curved; and we found that Divini's idea was carried out further by an optician of L on in 1668 (cited under my notes on Hooke's microscopes), who used two pairs of these lenses in his microscope. Grindl combined with the latter eye-piece a pair of similar (but smaller) lenses acting together as an objective, as shown in the diagram.

The form of the stand appears to have been copied from that of Chérubin d'Orléans, modified, however, by the application of an external screw to the body-tube acting in a screw-socket for focussing.

Bonanni's Microscopes. — In Bonanni's "Micrographia curiosa" (Rome, 1691, 4to), p. 26, we find the microscopes shown in Figs. 34 and 35. The interesting point in the design of Fig. 34 is that the focussing can be effected by a "screw-barrel" arrangement acting on the object, which is clipped between two plates and pressed away from the object-lens by a spiral-spring. This system of focussing was shown more practically (as we shall see) by Hartsoeker (1694), in combination with a condensing lens; and Hartsoeker's design was clearly the original of Wilson's (1702).

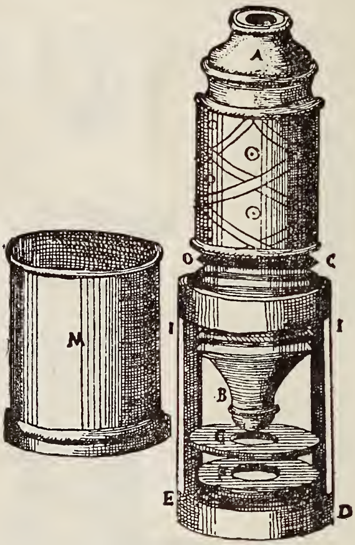
Fig. 34.



Microscope of Bonanni.

In Fig. 35 the focussing is effected by rotating the body-tube in a screw-socket. The plate, G, was fixed; the object was slid between F and G, and a spiral-spring within E D pressed it in contact with G. The tube, M, was put as a sheath over E I, D I, to exclude all light but that transmitted by the object when the instrument was directed to the sky. The design of this microscope is similar to, but an improvement on, that of Cellio (*vide* Fig. 32, *Fig.* 10), which was but slightly modified from Campani's, as we noted.

Fig. 35.

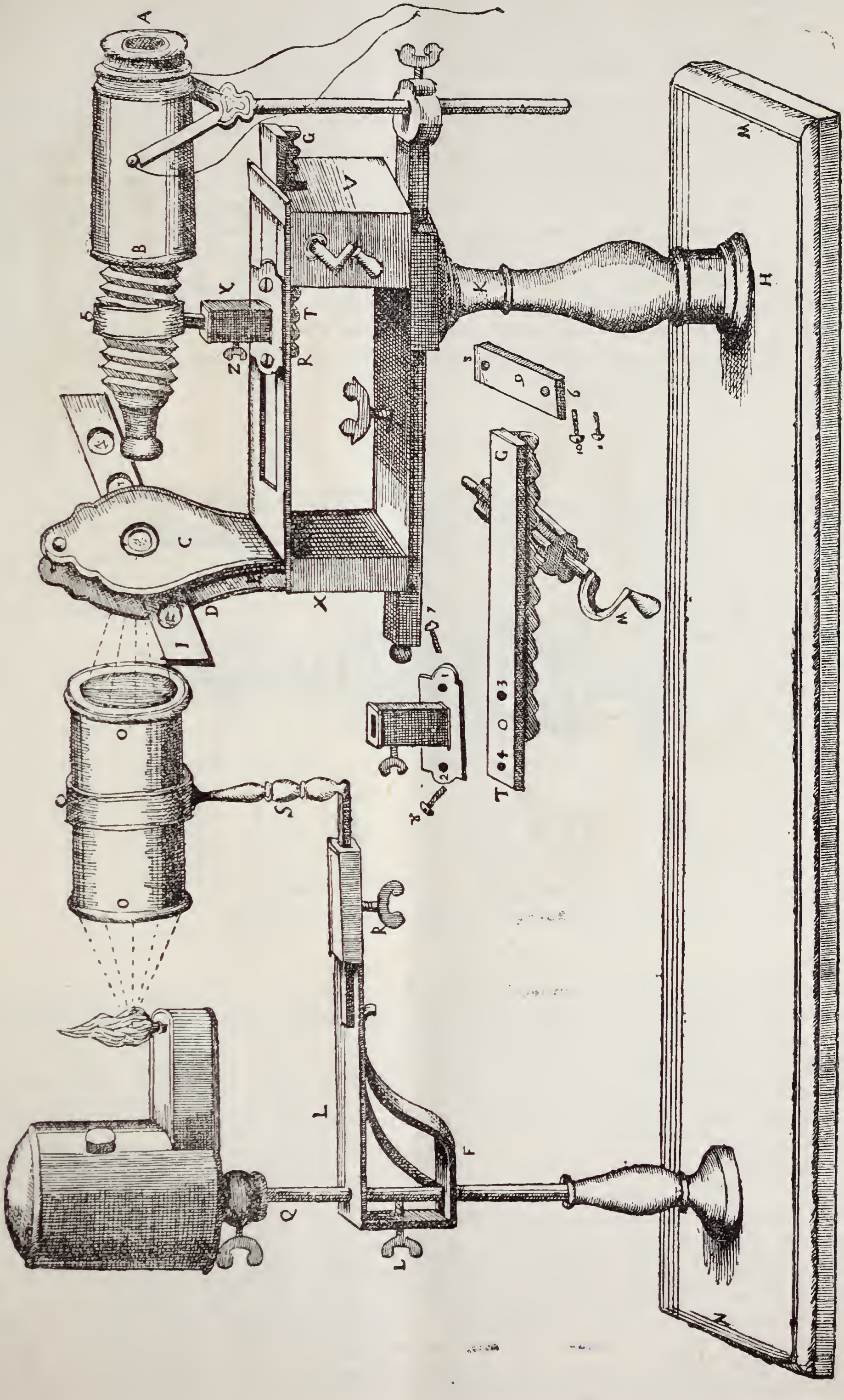


Microscope of Bonanni.

Bonanni is better known as the author of the horizontal compound microscope in Fig. 36 (p. 1035), which is copied from the original in the same work, p. 28. The convenience of using the microscope in a horizontal position, with a lamp and condenser in the same axis, is obvious, especially in view of the fact that nearly all the compound microscopes designed previously had to be used vertical, or directed to the sky. The mechanism appears to modern eyes somewhat primitive; but we must not be too exacting in our criticisms on this point, We have to acknowledge our obligations to Bonanni for initiating the system of the horizontal microscope, and for a graphical presentation of a compound condenser fitted with focussing mechanism for illuminating transparent objects by transmitted light.

Hartsoeker's Simple Microscope. — In Hartsoeker's "Essay de Dioptrique" (Paris, 1694, 4to), p. 175, we find the microscope shown in Fig. 37 (p. 1036). I must at once call your attention to the fact that in every essential point of design, Hartsoeker's microscope anticipated Wilson's "screw-barrel" microscope (published in the "Phil. Trans.," 1702), which became so popular in the 18th century. The lens-carrier, A B (on which the cell, P, containing the lens, is screwed), screws into the body

FIG. 36.

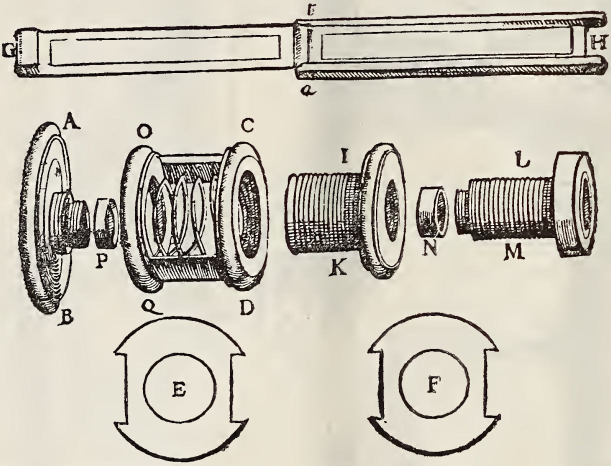


BONANNI'S HORIZONTAL COMPOUND MICROSCOPE (1691).

O C, Q D, at O Q; the thin brass plates, E and F, fit within the body, the portions cut out allowing them to slide on the short pillars, O C and Q D, and the spiral-spring pressing them towards C D; the object-slides, or an animalcule cage, G H (hinged at *a b* to allow the lid, G, to fit into H, enclosing the objects between strips of talc), slide between the plates, E and F, when in position, and the "screw-barrel," I K, fits into the screw-socket, C D, and regulates the focussing; a condensing lens, N, fits on a second "screw-barrel," L M, which is applied in the screw-socket of I K. This arrangement of the condenser is better than the plan adopted by Wilson, as it allows the illumination to be focussed on the object independently of the focal adjustment of the object to the magnifying lens; whereas, in Wilson's microscope, the condenser being mounted in I K, without facility of adjustment, remained at a fixed distance from the object, and hence the control of the illumination was very limited.

Hartsoeker appears to have been an expert in microscopical observations at a very early age. According to his "Éloge" by Fontenelle, when still a student of geometry, he constructed microscopes of blown-glass globules, and used them in the observation or discovery of minute forms of life with so much success, as to excite the jealously of Leeuwenhoek. His skill in the construction and use of the microscope brought him to the notice of Huyghens, by whose recommendation he was made a member of the "Académie des Sciences," of Paris.

FIG. 37.

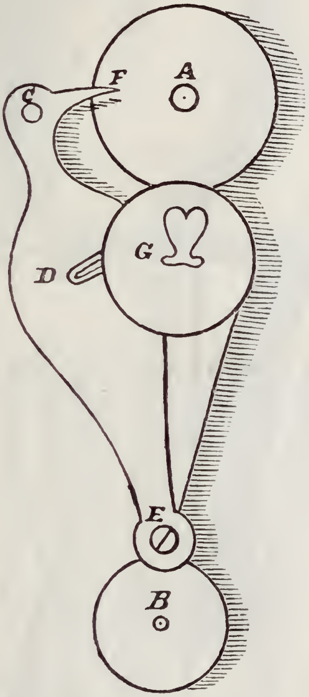


HARTSOEKER'S SIMPLE MICROSCOPE (1694).

In mentioning Huyghens in connection with microscopes, it may not be uninteresting to note that in Vol. X (1730), pp. 608-9, of the "Mém. de l'Acad. Royale des Sci.," it is stated that in 1678 he reported having brought microscopes from Holland, consisting of "minute spheres of glass," some of which were not larger than a grain of sand.

Gray's "Water Microscope."—In the "Phil. Trans.," XIX. (1696), pp. 353-6, Gray communicated the design of his water microscope, shown in Fig. 38 (p. 1037), together with notes on its use. He had previously figured and described (*ib.*, pp. 281-3) a simpler form, consisting of a plate of brass with minute holes in which drops of water were to be placed, but without arrangements for holding the objects to be examined. Here, however, we have an object-holder, C D E, pivoted at E on the lens-carrier, A B, the point, F, serving for such objects as could be fixed upon it, while the hole, C, was intended for drops of the fluid to be examined; G is a thumb-screw acting through the plate, A B, by which the object-carrier was focussed under the water-lens at A, the slot, D, enabling the carrier to pass the screw, G, the disc under G serving as a "washer;" the carrier was made of well-hammered brass, and sprung somewhat up from E so as to follow the movement of G. At A was a concavity about 1-8 inch in diameter, with a hole through the plate 1-32 inch in diameter—the plate itself being 1-8 inch thick —and on the other side was a corresponding concavity of 1-16 inch diameter, the two meeting in an edge in the plate. Drops of water were put in these concavities, forming a biconvex lens of unequal curvatures, by which, with care, interesting observations could doubtless be made. At B a cylindrical hole 1-10 inch was made, and in this either a shallow lens was formed by not inserting too much water, or a fluid containing organisms was inserted gradually until both surfaces were deeply convex, then, applying the eye suitably, one was expected to see the organisms by means of pencils that had undergone total reflexion within the water before being refracted to the eye—which process of observation was, I should say, both ingenious and useless.

FIG. 38.



GRAY'S "WATER MICROSCOPE" (1696).

In the early part of this century Brewster attempted to revive the use of fluid lenses, in some experiments following those of Gray, with modifications. Gray had made lenses by allowing drops of a warm solution of isinglass to solidify on plates of glass, either on the upper surface or suspended beneath. Brewster improved on this plan by using drops of Canada balsam, which would dry hard and be more transparent and less liable to injury. He also proposed (in conjunction with Dr. Blair) a number of combinations of fluids and lenses to obtain achromatism, and, in fact, he appears to have sought to exhaust the subject of fluid lenses. Many of Brewster's favourable criticisms* on the fluid lenses he devised have failed of any practical issue; and, except by here and there an enthusiast—especially those who are unaware of Gray's and Brewster's priority—lenses consisting of drops of water, or other fluids, applied with more or less ingenuity to form practical microscopes — are generally regarded as things of the past, not worth reviving. The possibility of seeing objects greatly magnified by means of a drop of water used as a lens should be known to botanists and others who may happen, in an emergency, not to be provided with better means.

Wilson's Microscopes.—In the "Phil. Trans.," XXII. (1702), pp. 1241-7, we find a description, with four *Figs.* of the two "small Pocket Microscopes" shown in Fig. 39 (p. 1038). *Fig.* 1 is the simple microscope that was termed, later on, the "screw-barrel;" its resemblance to Hartsoeker's instrument is obvious. The object-lens (of which there were seven of different foci, *Fig.* 2 representing the lowest power, mounted in "a little Barrel Box of Ivory") was mounted in the disc, B, screwing in the tube, A A, below; the object-slide, as *e e*, or an aquatic tube, *g g*, was applied in the the centre between the plates at E E, the spiral-spring, H, pressing it upwards; D was a hollow cylinder with an exterior screw-thread travelling in a screw-socket at the upper A A, thus controlling the focussing. C was a cell, containing a condensing lens, forming a convenient grip for actuating the screw movement of D. In action, the lens in B was applied to the eye, and the instrument directed to the sky or other source of light.

This form of microscope, with slight modifications, became very popular in the 18th century. It was originally made of ivory; but the great majority were of brass; occasionally it was made of silver. Its great success was probably due to its simplicity, whence it could be produced in large numbers at very moderate cost. The size rendered it easily portable, and the design was so plain and substantial, that it could be used by the veriest novice without risk of injury. The form lent itself readily to the application of a handle; then it was easily mounted on a pillar, and used

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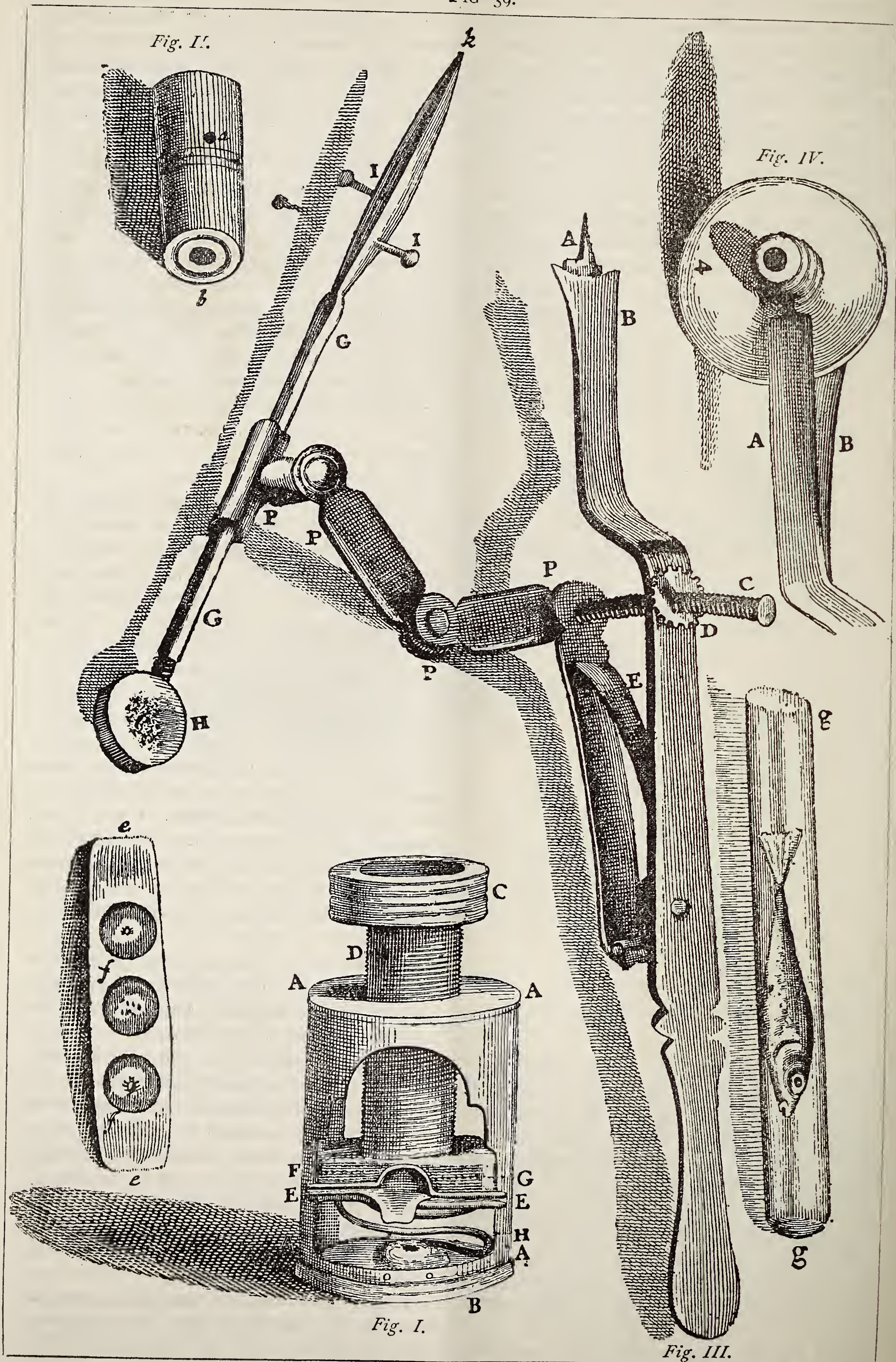
* Published in his "Treatise on New Philosophical Instruments," Edinb. (1813), 8vo., in the "Edinb. Encyclop." (Art. "Microscope"), in the "Encyclop. Britan." (7th and 8th editions, Art. "Microscope"), and many other works.

Fig 39.



Wilson's Microscopes (1702).

with or without a mirror; a very simple addition rendered it convenient for viewing opaque objects; the compound body could be added without difficulty, which was done by Culpeper, as we shall see, and diaphragms were applied to the condenser; with slight modifications it was combined with various forms of heliostat, thus becoming an essential feature in the solar microscope; and, combined with a system of large condensers, it became the lantern microscope, as used far into this century.

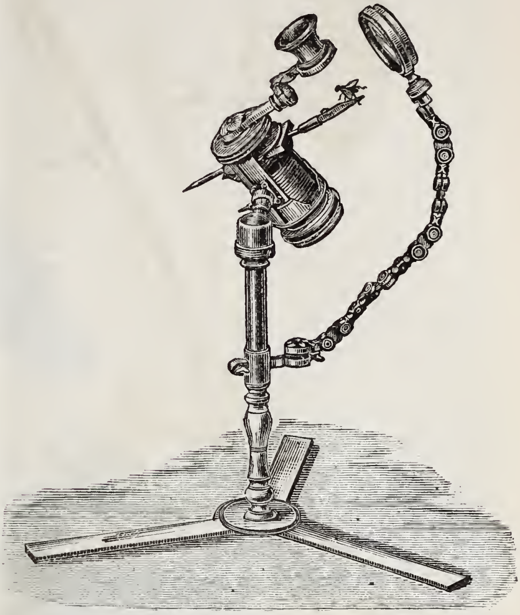
Fig. 3 shows the "opaque microscope" devised by Wilson. The series of magnifiers made for the above instrument were also used with this; they were each provided with a small hole, at the side of the ivory cylinder in which the lens was mounted, by which they could be fixed on the spike, A (as shown in *Fig.* 4). The object was held by "a small pair of Tongs, G G," or placed upon the black or white side of the ivory disc, H, at the other end. The focussing was effected by the milled nut, D, acting on the screw, C, which was fixed in the arm, P, the spring, E, giving the reverse motion when the nut was turned the opposite way. The pivoted arms gave ample range of motion to adjust the object under the lens.

This instrument was a decided improvement on Cuno's Simple Microscope (Fig. 31), and on the Italian form shown in Fig. 32, *Fig.* 4.

Before passing on to the examination of other models, we will note upon some of the modifications of Wilson's "screw-barrel" microscope that were devised in the 18th century.

(1.) *Culpeper's Simple Microscope* (Wilson's form).—Fig. 40 shows Culpeper's application of a folding tripod base with pillar to Wilson's model, with the addition of the lens-carrier on an arm to enable the instrument to be used with opaque objects. I have not been able to fix the date of this instrument; but as none of the examples I have seen were furnished with "Lieberkühns," we may infer the construction was probably anterior to 1738. A ball-and-socket joint supports the microscope, and with so small an instrument it was not so defective as with larger ones on the pillar. A complex system of articulations clamped on the pillar carries a condensing lens for illuminating opaque objects, or a plane mirror, as in Fig. 41 (p. 1040). For viewing opaque objects the lens was removed from the body-tube, and a disc, having a pivoted arm terminating in a ring, substituted; the low-power lens, in a horn mount was then screwed in the ring, and was thus held some distance away from the body of the instrument, so that the object could be properly illuminated. This arrangement is shown in the Figure.

FIG. 40.

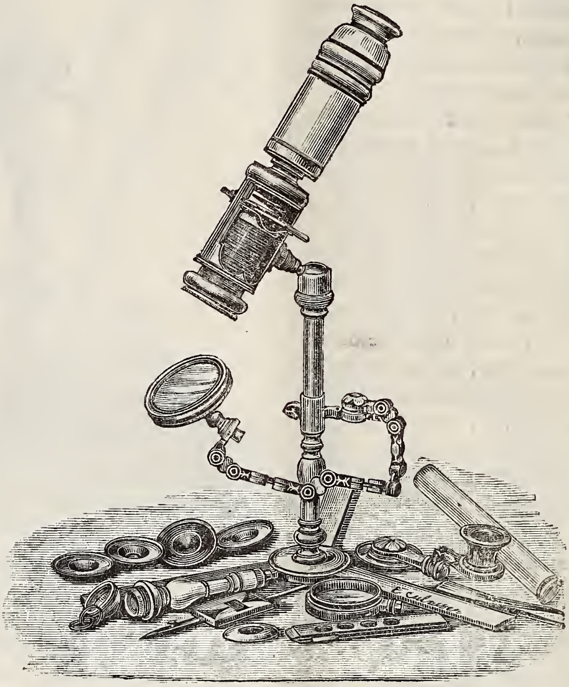


CULPEPER'S SIMPLE MICROSCOPE (WILSON'S FORM, *ante* 1738 ?).

(2.) *Culpeper's Compound Microscope.*—In Fig. 41 we have the same instrument as the preceding, but with a compound body-tube of ivory, with draw-tube substituted for the lens-carrier. A plane mirror takes the place of the condensers on the articulated arm; in later constructions, Culpeper applied the mirror on one of the feet in a line with the optic axis. A set of three diaphragms (of which one is shown in front) can be placed over the condenser in the lower end of the "Wilson" screw-barrel. The ivory handle is shown, on which the "Wilson" is held when unscrewed from the ball-and-socket; the box end is unscrewed where discs of talc, and brass wire rings, for holding the talcs in cells, were stored. An early form of animalcule cage is shown in front, having four concave discs of glass mounted in apertures in a plate on which a similar plate, with four corresponding apertures and plane discs, is hinged to open or close.

The instruments of Culpeper's manufacture were sometimes covered with ornamental engraving. In this example, the lens-carrier for opaque examinations, the forceps-plate, the articulated mirror-arm, the tripod, and the disc at the base of the pillar are engraved in this manner; and I have met with other examples in which the Wilson "screw-barrel" was similarly engraved.

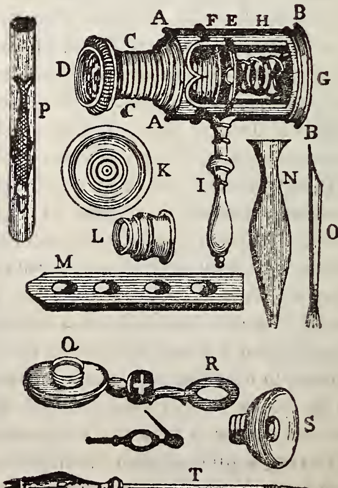
FIG. 41.



CULPEPER'S COMPOUND MICROSCOPE (*ante* 1738 ?).

(3.) *Wilson's Simple Microscope* (as made by Adams).—In Adams's "Micrographia illustrata" (1746, 4to), Pl. 5, we find the Wilson "screw-barrel" microscope, shown in Fig. 42. The lens-carrier, Q R, for opaque work, is similar to that made by Culpeper. The forceps-plate was (apparently) no longer in vogue, though it was useful with the Wilson model, as I can testify by practice. A lens combined with a "Lieberkühn" is shown at S, which enables us to fix the date as later than 1738.

FIG. 42.

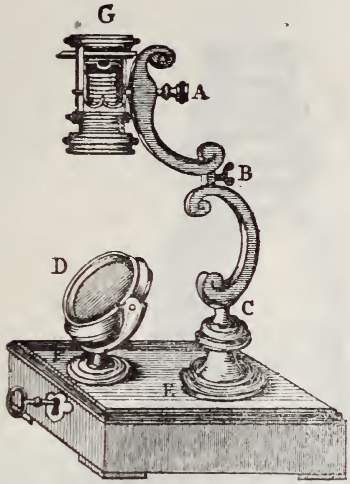


WILSON'S SIMPLE MICROSCOPE (AS MADE BY ADAMS, 1746).

(4.) *Wilson's Simple Microscope on Scroll Standard* (as made by Adams).—In the same work *(loc. cit.)* the Wilson model is shown mounted on a scroll standard, and with a mirror mounted on the base in a line with the optic axis (Fig. 43, p. 1041).

One of the most symmetrical arrangements of the Wilson model (and of the adaptation of the compound body) that I have met with, was constructed in the last century by Cramer, of Groningen, Holland. The "Wilson" part is of brass, the lens-mounts, the compound body, and draw-tube are of ivory, the scroll standard is of brass with ornamental chasings, and the shaped ebony base stands on three chased ormolu claws, the whole fitting in a truncated pyramidal box.

FIG. 43.



WILSON'S SIMPLE MICROSCOPE ON SCROLL STANDARD (AS MADE BY ADAMS, 1746).

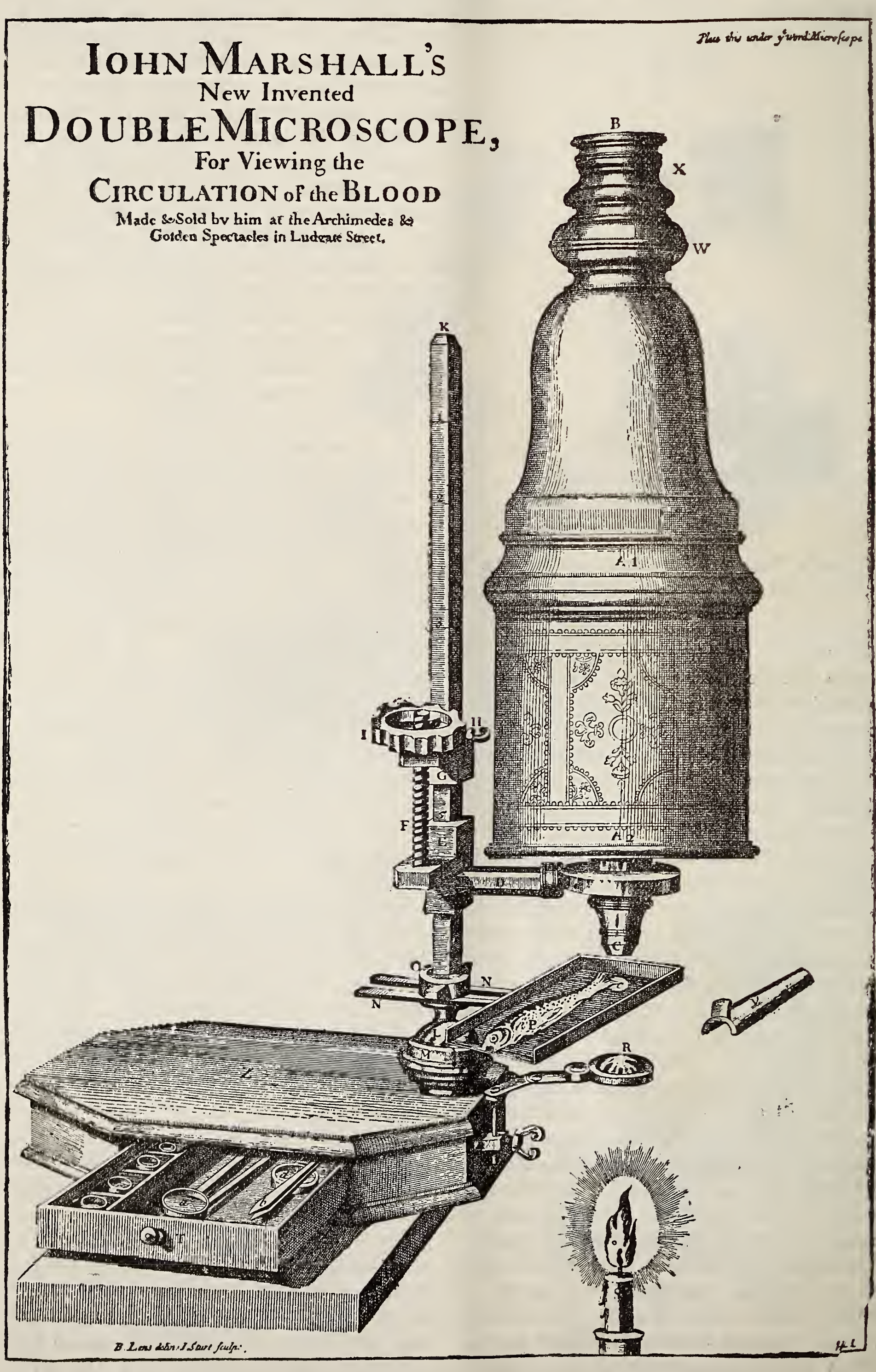
Marshall's Compound Microscope.—In Harris's "Lexicon technicum" (1704, 2 vols. fol.), under the word microscope, Marshall's compound microscope (Fig. 44, p. 1042) is described and figured. Several important innovations in microscopical construction were here embodied. (1.) A fine-adjustment screw, F, is connected with the sliding socket, E, supporting the arm, D, in which the body-tube is screwed; the focussing could thus be controlled in a far more effective manner than by any system previously applied to a large microscope. The previous systems involved the direct movement of the body-tube, either by rotating in a screw-socket (as in Hooke's), or by sliding in a cylindrical socket (as in Divini's and Chérubin's); in a few instances the object was moved in relation to the object-lens; but all these plans were more or less defective, especially with microscopes of large dimensions. Marshall's system was a distinct mechanical improvement, for the object could now be viewed during the actual process of focussing, as the image would remain steadily in the field. (2.) Hooke's arrangement of a link to encircle the pillar and carry a rotating stage, is here modified into a fork, N N, and, instead of being clamped on the base by a thumb-screw on the fixed pillar, it is here applied with a similar thumb-screw clamp, O, on the pillar itself. (3.) Hooke's ball-and-socket joint, which was applied to the arm, I, is here shifted to the lower end of the pillar, where it would give the movements of inclination to the whole microscope, instead of to the body-tube only, as in Hooke's; the ball, L, could be tightly clamped by the screw-collar, M, in which slots were cut to give spring. In one example I have met with, the slots were not cut, whence I infer that it may have been one of the first of the kind constructed, before the slots were applied. (4.) A condensing lens on jointed arms appears; I think this was the first application of such adjustments to the condenser. From the singular position of the candle beneath the condenser, I think we may infer, without doubt, that the mirror was still unknown as a microscopical accessory in England.

As a matter of fact, I have met with this model of Marshall's microscope bearing the date, 1718, still without mirror. The earliest instrument I have seen provided with a mirror was a modification of Marshall's, in which the ball-and-socket was replaced by a rigid pillar, and the open-link stage-carrier was replaced by an arm, attached to a socket rotating on the pillar, and fitted with appliances decidedly in advance of those figured by Harris, or indeed of any belonging to actual models I have seen of Marshall's; and the date of the construction I should assign would be 1718-1730—probably earlier than the Culpeper instruments we have examined, in which the articulations of the mirror-support point to an experienced use of the mirror.

Harris commends Marshall's arrangement of the fish-trough with the "Lead Coffin," M, "to be put on the Fish to hinder it from springing away, and moving his Tail out of the Light" while under examination. The series of object-lenses were apparently regarded as novel in connection with a compound microscope. The numbers on the standard were to indicate approximately the position of the coarse adjustment for the different powers. To counterbalance the instrument when in use, as figured, the opposite end of the base had a large block of lead fixed inside.

The figure of Marshall's microscope has been reproduced very frequently in Encyclopædias, and other works; and occasionally the position of the candle has been said to be more favourable for depositing soot on the condenser than for illuminating the object. The instrument should be judged by com-

Fig. 44.



IOHN MARSHALL'S
New Invented
DOUBLE MICROSCOPE,
For Viewing the
CIRCULATION of the BLOOD
Made & Sold by him at the Archimedes &
Golden Spectacles in Ludgate Street.

Place this under y^e word Microscope

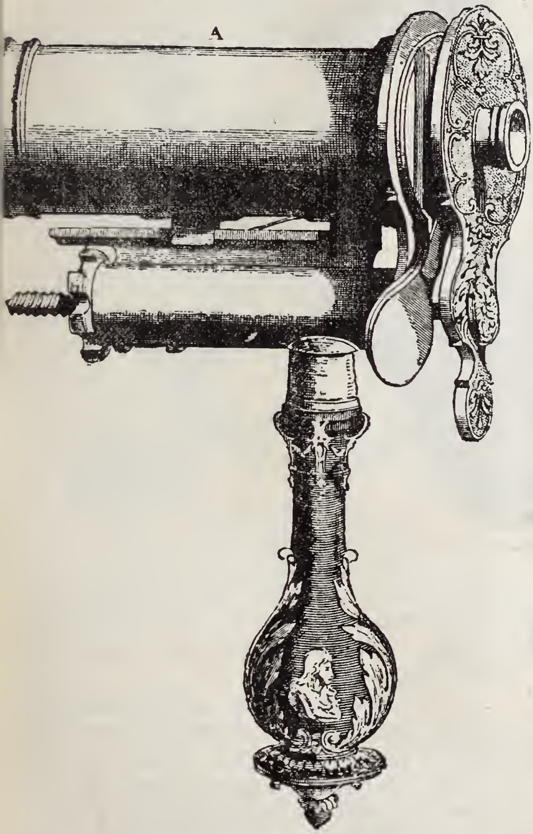
B. Lens delin: I Sturt sculp:

(1704).

parison with the microscopes of its day. Harris tells us that Mellen's and Leeuwenhoek's simple microscopes were the best then in use, and he concludes his notice of Marshall's thus:—"I have had *Mellen's* Glasses, and seen *Lewenhoeck's* and *Campani's*, but I would sooner have the *Double Microscope* [Marshall's] than any of them, and the price is much easier."

Joblot's Simple Microscope.—In Joblot's "Descriptions et usages de plusieurs nouveaux Microscopes" (Paris, 1718, 4to), several different forms of microscopes are figured and described. I select the one shown in Fig. 45 as typical, at least, of the ornate designs proposed by Joblot. The lens was mounted in the small cylindrical tube in the centre of the vertical plate on the right, to the lower part of which a rod was attached passing into the lower horizontal tube, and with a screw at the other end acted upon by a nut for focussing.

Fig. 45.



Joblot's Simple Microscope (1718).

Joblot's principal claim to recognition as a designer in connection with the evolution of the microscope, is the fact that he devised a rotating object-stage (applied to the model here figured) that may have suggested to Oberhaeuser the plan he worked out so successfully; but on this latter point I speak with reserve, for the similarity in the mechanism is not a proof that the one was based on the other.

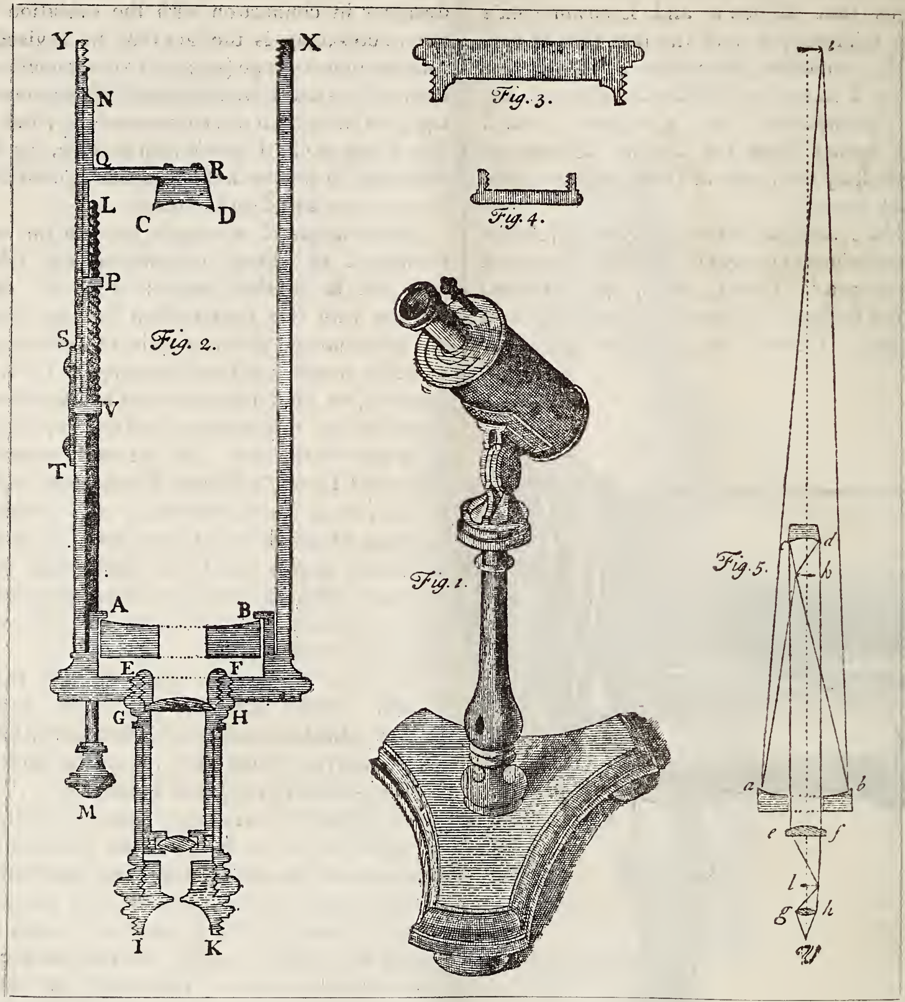
Joblot mounted a simple lens on an arm composed of three ball-and-socket joints attached to a short stem; it is in connection with this construction that his name has been handed down to us in the succession of works treating of the microscope. He was, however, so distinctly preceded by Musschenbroek in the essentials of his design, that I pass over that form. For the same reason I pass over Lyonet's Simple Microscope, which differed from Musschenbroek's and Joblot's, in being attached to an oval stage of wood, supported at one end by a brass pillar connecting it with the base, and with an aperture through which the light from a mirror was reflected on the object.

Barker's "Catoptric Microscope."—In the "Phil. Trans." XXXIX. (1736), pp. 259-61 (5 Figs.), Barker described this instrument (Fig. 46, p. 1044) as "contrived .... on the Model of the Newtonian [Gregorian] Telescope...." It was arranged to magnify "from the Distance of 9 Inches to 24 Inches," so that opaque objects could be easily illuminated and viewed. The focussing was effected as with the Gregorian telescope, *i.e.*, by means of a rod and screw, M L, (*Fig.* 2) acting on the small concave speculum, C D. The eye-piece had a plano-convex field-lens, G H, and a bi-convex eye-lens. The instrument was mounted on a cradle-joint on the top of a pillar, and was not connected with the object (*Fig.* 1).

The construction was simply that of a Gregorian telescope of very short focus, with an extra range of movement for the small speculum to focus objects distant only from 9 to 24 inches.

The diagram, *Fig* 5, shows the path of the rays from the object to the eye. By bringing the small concave nearer the large one, more and more distant objects would be viewed, until the instrument would become a telescope proper; thus furnishing an example of the conversion of a microscope into a telescope, or, conversely, "Thus a telescope used for viewing very near objects becomes a *microscope*," as stated by Herschel ("Encyclop. Metrop.," art. "Light," p. 403).

FIG. 46.

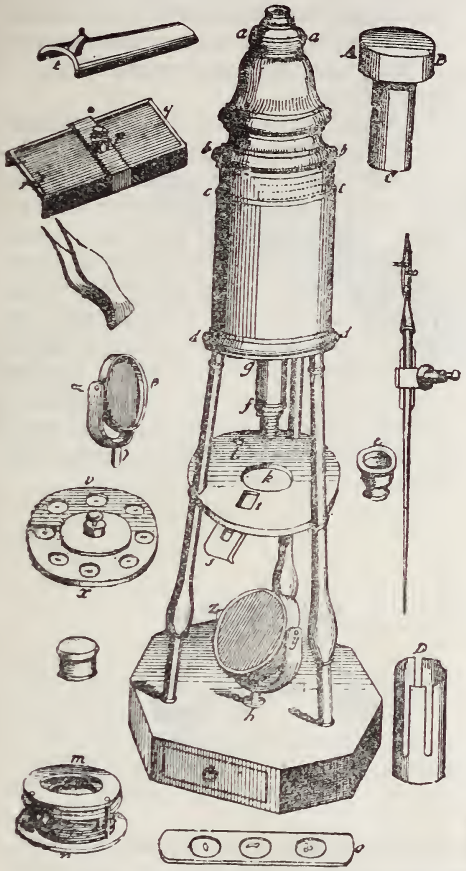


Culpeper and Scarlet's Compound Microscope.—This microscope (Fig. 47, p. 1045) was published in R. Smith's "Opticks" (Camb., 1738, 2 vols., 4to), I., p. 407, and was considered by Smith as a better form than any that preceded it. From our point of view this commendation appears strange, for the general design does not suggest a convenient working instrument. There was no fine adjustment, and the focussing was effected by sliding the body-tube in the socket. A rotating multiple object-disc, *v x*, is seen (reversed in the Fig. to show the "button" in the centre by which it was fitted in a slit, *i*, and held by the small brass sliding plate, *s*, under the stage). The spring-stage, *m n*, fitted in the aperture, *k*, and acted after the manner of modern safety stages. The fish-trough, *q* (shown reversed), was applied at *i*, and the "coffin," *t* (devised by Marshall), held the fish still. From Smith's reference to the "concave looking glass, *y z*," I think we may infer that the application of a mirror was new to him.

Smith mentions that he had occasionally used this model as a Reflecting Microscope, after the method explained by Newton (see Fig. 18). For this purpose he removed the mirror, *y z*, and substituted the slotted spring-tube, D, in which a concave speculum, cemented on the top of A B, was adjustable by means of a small wooden cylinder, *c*, beneath; then he removed the field-lens from the eye-piece and the object-lens, *f*, from the body-tube, placed an object on a piece of clear glass at *k*, condensing light upon it by the lens, $\alpha\ \beta$, applied at *l*, and by sliding the speculum up or down, and adjusting the eye-lens correspondingly, so that the object and its image were the two conjugate foci of the speculum, he saw the magnified image at *a a*.

The general design of this microscope was much in vogue in the 18th century, and was modified by Adams, Dollond, and others. In some instances the pillars were made very ornate, especially by Italian opticians. Adams added a fourth pillar, and applied a rack-and-pinion to the body-tube and socket for focussing. In odd examples I have met with, the construction of which suggested that they were probably made by Brander, of Augsburg, the socket of the body-tube was hinged on the stage by two short pillars, so that the upper part could be inclined in relation to the stage. The Nürnberg toy-manufacturers seem (as I have already noted) to have popularised this tripod form, probably because the design could be carried out easily in wood and cardboard at a small outlay; occasionally they applied two or more draw-tubes, and added to the body-tube an arrangement similar to Bonanni's (Fig. 35) for holding the objects.

Fig. 47.



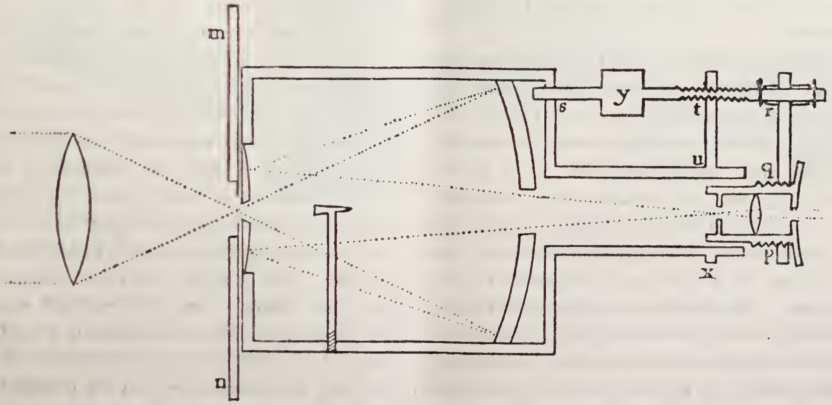
Culpeper and Scarlet's Compound Microscope. (1738).

Smith's Reflecting Microscope.—In the same work (II., pp. 95-7, Fig. 169), the construction of a reflecting microscope of the Cassegrainian form, shown in Fig. 48, for viewing transparent objects, is given in detail.

This microscope was similar to the Cassegrainian telescope, but with an extra long eyepiece tube to permit the focussing by movement of the eye-lens. The object was placed at M N; the image was taken up by the concave, reflected on the convex, and again reflected to the eye-lens. He advised the use of a condensing lens for the illumination, to prevent "the mixture of foreign rays with those of the object," otherwise the instrument gave confused images of distant objects when it was used as a microscope.

In the one instrument of this form I have

Fig. 48.



Smith's Reflecting Microscope (1738).

examined, the objects are magnified very clearly, though there is no condensing lens.

Lieberkühn's Simple Microscope (as made by Adams).—About 1738, Lieberkühn devised a combination of a simple lens, mounted in a central aperture in a polished metal reflector, which he applied to a small hand-microscope (similar to the second form of Wilson's, *vide* Fig. 39) for the special purpose of viewing opaque objects. Fig. 49 shows the microscope as made by Adams (*vide* "Microgr. illustr.," *loc. cit.*). The combination of a lens and reflector (shown at K) is practically identical with that of Descartes (1637), but the application to a convenient hand-microscope rendered it infinitely more serviceable. As proposed by Descartes, the object had to be viewed as it happened to be attached to the spike, and required complete re-adjustment for every different view; but Lieberkühn's application by which the lens was no longer fixed to the object-carrier, left the latter free to be turned and adjusted as required by the forceps, &c.

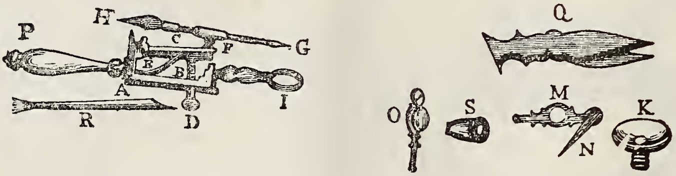
Cuff, the English optician, is stated to have improved upon Lieberkühn's original construction (where one reflector served for lenses of different foci) by making a series of reflectors to correspond with the foci of the lenses, so that the objects were more perfectly illuminated.

Lindsay (1742) used not only spherical concave reflectors, but also hollow cones of polished silver.

Dellebarre (1777) made extra large reflectors of silver, and also of silvered glass, for his compound microscope (*vide* Lalande's description in Montucla's "Hist. des Mathématiques," 2nd ed., 1799-1802, III., p. 511). In several of Dellebarre's microscopes that I have examined, the large perforated silver mirror was adjustable on the nose-piece of the body-tube, with a range of upwards of an inch of screw-motion.

The "Lieberkühn" was readily modified in construction so that it could be applied to achromatic objectives by means of a cylindrical tube sliding on the end of the mounting, and has thus held its own to this day.

Fig. 49.

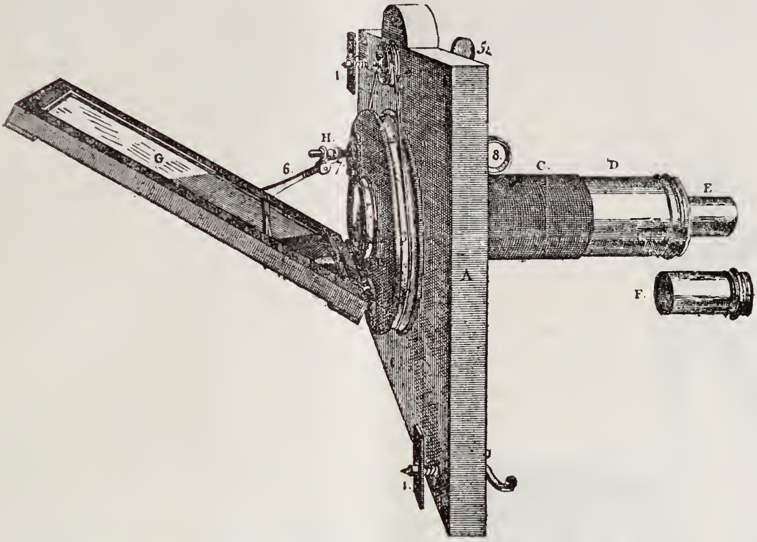


Lieberkuhn's Simple Microscope (174[illegible]).

Charles Chevalier (1830) made use of a perforated silvered mirror of glass to avoid the inconvenience of tarnishing, especially where chemical re-actions were under observation. Amici (1840) made some extremely small "Lieberkühn's;" in one I have met with, of silver, the concavity was less than 1-8th inch in diameter.

Lieberkühn's Solar Microscope (as improved by Adams). — Lieberkühn was the inventor of the solar microscope (1738). As first devised, there was no mirror, the microscope with the condenser had thus to be directed to the sun, which was done by means of a "Scioptric Ball and Socket," and the screen upon which the magnified image was projected had to follow the movement of the microscope. The English optician Cuff is said to have improved upon Lieberkühn's arrangement by the application of a mirror (heliostat) with mechanism, by which the sun-light could be directed constantly through the microscope, and the magnified image projected on a fixed screen. In the earliest form of solar microscope I have seen by Cuff, the rotation of the mirror on the axis of the microscope was effected as shown in Fig. 50, p. 1047 (copied from Baker's "The Microscope made easy," 3rd ed., 1744, p. 22), by means of a cord encircling a large grooved wooden disc, B, on which the mirror was hinged at one end, and carried over a second and much smaller disc or wheel, 4, connected with a thumb-screw, 5; the other movement of the mirror being controlled by a rod, H, connected with the mirror-frame by a jointed arm, 6, and passing through a metal friction-socket in the rotating disc, B, terminating in a ring, 8, by which it was moved. The heliostat was also made in this way by Martin in his earliest examples. The arrangement was improved shortly afterwards by making the moving parts of brass; the disc, B, was toothed on its circumference, and a pinion controlled the rotation; a worm-wheel and endless-screw gave the other motion. I cannot say who devised these improvements; the latter one was, however, shown by Adams in 1746 ("Microgr. illustr.," Pl. IV.), together with his application of his "New Universal Single Microscope" (Fig. 51). Martin claimed the former, if not both; at any rate, in his "Micographia nova" (1742), his description of the solar microscope refers only to a "Scioptric Ball and Socket" arrangement, so he did not know of the application of a mirror at that date.

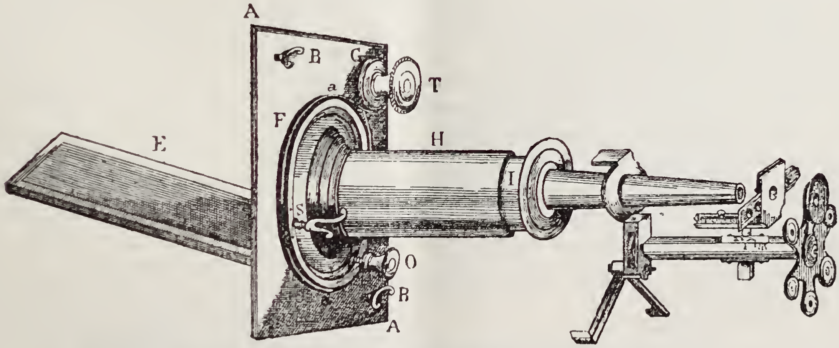
FIG. 50.



LIEBERKUHN'S SOLAR MICROSCOPE (AS IMPROVED BY CUFF, 1744).

The various references to the use of the solar or *Camera obscura* microscope, published in the last century, show that far too much was claimed for it. Martin, Adams, and Baker seemed to vie with each as to who could speak of it in terms of highest admiration, admiration which is now seen to be out of all proportion to the solid merits of the instrument. The modifications by which the lucernal microscope was developed—where a lamp was used instead of sunlight, and the image was received on a ground-glass screen—may have contributed to render the microscope a means of amusement, but I do not think these applications have added to its scientific value, certainly not in a measure proportionate to the attention they received at the hands of the opticians.

FIG. 51.

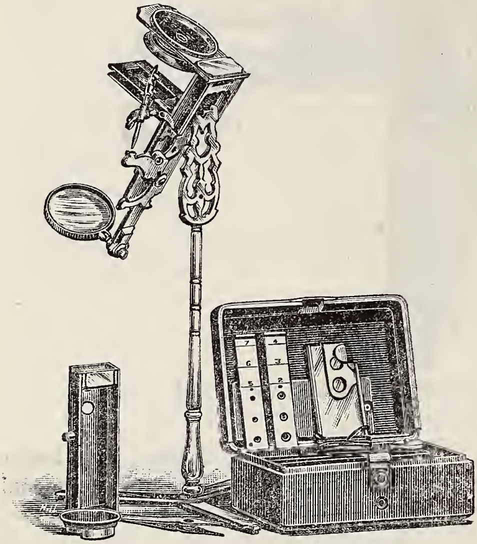


LIEBERKUHN'S SOLAR MICROSCOPE (AS IMPROVED BY ADAMS, 1746).

Lindsay's Simple Microscope.—This miniature microscope (Fig. 52) is of two-fold interest to us: (1), it was the first microscope for which a patent was registered (1742); (2), the design is so neat and compact and so novel, and the workmanship so superior to the rivals of its day, that one has a difficulty in accepting the fact of its construction in 1742.

The focussing is effected by a lever at the side raising or lowering the stage in grooves.

FIG 52.



LINDSAY'S SIMPLE MICROSCOPE (1742).

Single lenses are mounted in two plates (as shown in the box-lid) sliding in the grooved lens-carrier at the top of the instrument. The lowest power is mounted in a Lieberkühn reflector; and a hollow conical reflector is shown in front. The stage-forceps, fish-plate, mirror, jointed stem, folding tripod, &c., are all designed to pack with the instrument in the box about $4\frac{1}{2} \times 2\frac{1}{2} \times 2$ inches. The microscope figured is made of silver, and is one of the best examples of eighteenth century workmanship that I have met with.

Figs. 32-37, 39, 42-51, were reproduced from the original Figures in the works cited. Fig. 38 was copied from a tracing of the original.

My acknowledgments are due to the Royal Society for permission to reproduce Figs. 32, 38, and 46, from the "Philosophical Transactions."

Fig. 52 was photographed on the wood-block from the instrument.

ELEMENTARY LECTURES.

ELECTRICITY.

By PROFESSOR GEORGE FORBES.

Lecture IV.—Delivered May 8th, 1886.

In a previous lecture, when we were examining the current, we saw the means by which we could create electric currents, and we saw something of the way in which these electric currents act. It will be my endeavour to-day to show you some experiments illustrative of the enormous progress which was made during the years 1820 to 1830, the results of which have formed the foundation of the whole of the most important developments and practical applications of electricity since that date. Previous to the year 1820, there were but few phenomena known connected with the electric current. We knew that the electric current would heat up conductors; we knew that we could get a spark from the charcoal points from Humphry Davy's celebrated experiment, which led eventually to the construction of the arc light; we also knew that chemical substances could be decomposed by means of the electric current, but beyond that practically nothing was known. A certain number of facts, isolated and non-reproducable, apparently had been collected. It had been found that there was some sort of connection between magnetism and electricity, but as to the nature of this connection nothing was known. It had, however, been observed that frequently on board ship, during a thunderstorm, when a flash of lightning struck the vessel, the compass needle was either rendered useless, or it might be caused to point in the exactly opposite direction, its north end pointing south, and its south end pointing north. It appeared then that this electric current and the discharge of lightning had some connection with magnetism, but up to the year 1820, there was no clue as to what the connection between those two was. In my last lecture I showed you what very intimate connection there would now seem to be between electricity and magnetism; and every step of our progress to-day will show you the connection still closer. In the year 1883 there was a grand exhibition of electric appliances in Vienna, and I remember well, after wandering round that enormous building in the Prater, where was collected a display—the developments of electric science in every department—in telegraphy, telephony, electric lighting, electric clocks, and all kinds of electric appliances; after having examined all these dynamo machines, arc lamps, and other things, I came. in a secluded corner, upon a minute exhibit, which made me pause with a feeling of respect, and almost of awe, when I looked at this small apparatus, and thought of the consequences which had followed from the experiments made with it. This was simply a compass needle placed on a stand with a glass shade over it, and above the compass needle was a bust of the man who had used this simple apparatus. I assure you that when I thought of the experiment that had been made with that compass needle, and when I saw that, from that single experiment, the whole of the principles involved in the vast assemblage of electric apparatus in that building almost immediately followed, one could not help feeling that there was something to have respect for. I need hardly say, the exhibit I was looking at was the compass needle, and that the bust behind it was the bust of Professor Oersted, of Copenhagen. His grand experiment was the genesis of all that has been done in electro-magnetism since then, and I think that you and I shall be able to see this afternoon, as we take up one experiment after the other, how it might have been possible almost to have foretold from that one experiment a vast number of phenomena which were discovered afterwards, and which form the fundamental principles of our science. The experiment of Oersted was in bringing a wire through which an electric current was passing into the neighbourhood of a suspended compass needle. Here I have a compass needle suspended on a pivot. In my hand I hold a wire, through which I am able to pass an electric current by connecting its two ends with a battery. The direction of the current is shown by the arrow on this wire. The result is, that if the wire containing the current be held parallel to the needle, it will be deflected in one direction or the other, and the direction in which the magnet is deflected depends partly on the direction of the current, and partly on the position of the current above or below the needle. First, I place the current travelling from north to south, and I place the current over the compass needle. You will then see that the north pole, which is the one to my right, moves towards me, that is to the east. I reverse the current, and make it travel from south to north, and immediately the motion is checked, and more rapid motion in the opposite direction is produced. By reversing the direction of the current, then I am able, to reverse the direction of the motion of the compass needle. I will place the current travelling from north to south, but under the needle, and the north pole will go away from me instead of towards me as it did before. I reverse the current once more, and now it will be going from south to north, and then we shall see, when it is below, the north pole will approach me. Now let me show you what conclusions you might legitimately draw from these facts. It has nothing to do with the vertical position, except that the pivot being vertical the magnet can only travel in a horizontal plane, therefore we must not define the action as being dependent on the position of the current above or below. But I will give you a law which has been very generally used as a sort of aid to memory. If I be facing the magnet, and if my body be lying in the direction of the current so that I am as it were swimming with the current, the current coming in at my feet, and going out at my head, and if I be looking at the north pole, I shall see the north pole going to my left-hand side. That is a general statement that includes a statement for all cases. If it were a south pole I was looking at, it would be urged in the opposite way.

Another thing which follows immediately from this observation of Oersted's is this; it follows that each one of these poles is trying to go round the current. When I have the current near the compass needle the north pole is trying to go round the current, and would go round it continuously, but that it is restrained in its action by its connection with the south pole. Therefore, I have both the north pole and the south pole wishing to go round the wire in opposite directions; they cannot go round in opposite directions because they are rigidly connected, therefore the most they are able to do is to move in a position at right angles to the current. But we see clearly enough that if we could arrange matters so that only the north pole was tending to go round the current, and the current did not extend over the south pole, then we should be able to get continuous rotation of the north pole round the current. I think you will agree with me that is a conclusion we naturally have arrived at, and which ought to be evident from the experiment of Oersted. I will try that experiment with a small piece of apparatus I have on the table. It consists of a magnet which is in a bent form. The vertical magnet is pivotted by a wire at the top and bottom. The current goes down through the top pivot alongside of the north pole, but it is stopped at the middle of the magnet, and carried away by a wire dipping into a trough of mercury so that it does not come down near the south pole. It passes only in the neighbourhood of the north pole. If our conclusion is right, that north pole ought to travel continuously round the current, and we should have continuous rotation of this north pole round the current when we connect with the battery. The presence of the current is rendered evident by the luminosity of the little piece of platinum wire which is bent round so as to dip into the mercury cup. We find when it is adjusted that we shall get continuous rotation of the magnet round the current. I will now describe another experiment which is a simplification of this, a very remarkable thing, too. This consists of a compass needle north and south; it forms its own axis, being pivotted top and bottom, but there is a platinum wire as before dipping down into the mercury cup which carries away the current from the middle of the magnet, so that the current only traverses half the magnet, then passes away, and does not come near the south pole. In this case also the north pole, which is at the top, ought to travel round itself. This experiment illustrates it equally well with the other, although it is a step in advance, perhaps. The north pole rotates round itself in a continuous direction.

It appears, then, so far as the action of the current on a magnet is concerned, it is this. There is a tendency to cause the north pole to move perpendicular to the direction of the current, and for the south pole also to move perpendicular to the direction of the current, but in an opposite way. In other words, the current has the power of creating magnetic force in its neighbourhood, that is, of influencing a magnetic pole. If it has the power of creating magnetic force, we know that there are many things it is capable of doing, that it is not only capable of moving a magnetic pole, but that it is also capable of creating a magnetic pole in a piece of iron. And you remember in the experiments of last lecture I threw some images of iron filings on the screen in a magnetic field, and showed that the direction taken by those iron filings indicated to us the direction of the magnetic force; so you will easily see that we ought, if we sprinkle filings round the wire, to be able to see these lines of induction by circles round the magnetic pole. I will now throw this on the screen.

When we have a current going through a coil of wire, making a ring of current, what is the condition of the magnetic force? We know that any part of a coil through which the current is traversing is tending to move the north pole continuously round it in a certain direction. Every part, then, of the coil of wire is tending to move north poles round the outside of the ring and in through its centre; they all combine to tend to move the north pole through the centre of the coil. You remember that when I had this floating battery with this coil of wire attached there was a tendency for the magnet to suck this coil over itself, and now we see clearly that the opposite effect is capable of being produced, and that the coil would naturally tend to create a magnetic force through its centre, and a complete magnetic circuit would be established round its outside, and back again through its centre. This action can produce certain effects. This creation of a magnetic field can cause a magnet pole to be moved, so that if we have a compass needle suspended inside this coil the current would tend to turn the needle at right angles to the coil, the north pole being moved through the coil in one direction, and the south pole being moved in the other direction. This is the principle of the construction of our galvanometers, of which I have one on the table here. We have two coils of wire both wound in the same direction, and the current circulates through these wires. On the central stand there is a compass needle which naturally points north, parallel to the plane of the coils, but when the current is complete both these coils tend to move the north pole to the right if the current is in one direction, and the south pole to the left, or the north pole to the left, and the south to the right if the current is in the opposite direction. This is one of the actions which a coil can produce owing to the magnetic condition of the space in its neighbourhood.

Another thing which a magnetic force can do is to create poles in a piece of iron. Thus if I put this piece of iron into the centre of this coil, and if I hold a few iron tacks in my hand under it, they are not attracted, but if we turn on the current, those tacks will be attracted and hang there. The moment the current is broken the tacks fall down again, showing that this coil, with a current passing through it, created magnetic force in its neighbourhood, and is also able to induce polarity in a piece of iron.

The third action is the combined effect of the two. This coil has the power, when I suspend my iron by a piece of thread in front of, and co-axially with the coil, of creating polarity in the piece of iron, and then of causing the pole to move in accordance with the rules we have already described. On passing the current, you see the iron sucked into the coil. This sucking action is applicable to a great many pieces of apparatus, and I might illustrate it by a small piece of apparatus which has been called an electric hammer. Here is a vertical tube, wound continuously with a coil of wire from the bottom to the top. At every fifth turn there is a separate wire led away to one of these pieces of brass, of which there are in all fifty round the stand. The lowest five turns are connected with the piece of brass next to me; the second five with the next piece of brass; the third with the third piece, and so on, until the last piece furthest from me is connected to those coils which are at the very top of the column. If I introduce into this column a piece of iron, I have the means of causing any set of these turns of iron round the vertical column to have a current passing in them. The wires from my battery come to this piece of wood which has two contact pieces on it, and they just cover ten of these brass pieces on the flat board, so that by moving the wood along the flat board I make contact with the different pieces of brass, and I can send the electric current through any ten of these sets of turns which I please from the bottom of the vertical column right up to the top. Thus, if I introduce a piece of iron into the tube by making contact, and sending current through these coils, I can suck the iron right up to the top, and drive it down with very considerable force. I put a piece of paper on the top of the tube, so that you may see the rise of the iron. The force with which I am able to bring it down produces a very considerable blow. The arrangement, of which this is a model called an electric hammer, was shown in the Munich Exhibition of 1882 on a considerable scale, but more as one of the evidences of what we may expect the applications of electricity to lead to than for any purposes which it served at that time.

I have said that a study of these phenomena, resulting simply from Oersted's grand discovery, should lead us to many new facts even before we had performed the experiments, and I am going to ask you to think about that very connection in order that you may be led to one of Faraday's beautiful discoveries, and I believe that in so thinking over Oersted's experiment, and leading up to Faraday's great experiments, we shall be following somewhat in the path over which Faraday travelled. Faraday never told us that he knew beforehand what results he was going to get. He always described his experiments simply as they came, but at the same time I have little doubt he reasoned somewhat in this manner. We have found that a north pole tends to move in a certain direction round an electric current. Now it is a grand law which we have known since the time of Newton that action and re-action are always equal and opposite. Let me say a few words to show what I mean. If one of you and myself were sitting on two chairs on casters connected by a rope, and I was to pull, you must not imagine that you alone would be pulled along the floor towards me, I also should be pulled towards you, or if you were to pull both of us would be moved towards each other. In every case whoever may do the work there is always a re-action equal, and opposite in direction, to the action. When a planet is going round the sun, the planet is drawn towards the sun by the force of gravitation, but you must not suppose that the sun is not also drawn towards the planet; it most undoubtedly is. And although the mass of the sun is so great that its movement is small, the total amount of re-action is exactly equal to the action of the earth in moving towards the sun. When a stone falls from the hand towards the ground, it falls by the force of gravitation of the earth attracting it, but the stone is at the same time attracting the earth, and the earth moves in the opposite direction to the stone, and the total action which we observe by the fall of the stone is exactly equal to the reaction in that motion of the earth upwards to the stone, only the mass of the earth is so great that of course its motion is totally insensible. Now with these preliminary remarks, let us return to the experiments we have been considering. We find that a magnetic pole tends to rotate round an electric current. We know that action and reaction are always equal and opposite, therefore, before we try an experiment, we know with absolute certainty that a current will tend to rotate round a magnetic pole. This is the sort of argument which I have always imagined to myself Faraday must have used in studying Oersted's experiment as leading up to this beautiful experiment which he produced, showing that an electric current rotates round a magnetic pole. This apparatus is exactly the converse of that smaller apparatus which showed us the other experiment. Here I have a vertical magnet with its south pole uppermost. Pivotted on the top of the magnet is a conductor, a piece of copper wire in fact, which travels parallel to the magnet, and dips down into a trough of mercury. The current then enters the magnet, goes up to the pole at the top, traverses the pivot, goes down the wire which is parallel to the magnet, but outside it, then into the mercury, and back to the battery. Now, when we turn on the current, we shall find that the wire is rotating round, showing the accuracy of the principle, that action and reaction are equal and opposite. I have only to change the direction of the current in order to show you that the motion is in the opposite direction. I shall now simply show you the effect of reversing the polarity. You noticed that the wire went round, if you looked down upon it, in the direction of the hands of a watch. I have now reversed the magnet, and put the north pole uppermost, and we shall find that the current, which is in the same direction, will go in the opposite direction. This experiment led Faraday to a large number of very beautiful experiments, all illustrating the same point; but the general fact remains, that when we have an electric current in a magnetic field—that is to say, in a part of space where there is a magnetic induction—and cutting the lines of magnetic induction, then there is a force tending to move that current and tending to move the magnet, and whichever is free to move will move, and if both are free to move, both may move. I should like to say a little more about the direction. I told you, when I was using the suspended magnet, the law derived from Oersted's experiment was, that if you supposed yourself a conductor carrying a current, your head pointed in the direction of the current, and you looked towards the north pole, that then you would see the north pole moved to your left. Another way is to place the face of your hands with the palm towards the north-pole, and stretch your thumb away from your fingers, and point your thumb in the direction of the current so that the current may come down your thumb. If the current is coming from the point of your thumb towards your hand, and the palm of your hand is facing towards the north pole, then your fingers will show the direction in which the north pole of the compass tends to move. That is, perhaps, a little simpler than the way I previously described it. Another way has been put very clearly thus. Suppose you are using a corkscrew, you turn it round in the direction of the hands of a watch, and at the same time the corkscrew moves through the cork. That gives you a relative idea of the direction of the rotation, and a motion perpendicular to the plane of the rotation. Then I would say, when the current is going in the direction in which the corkscrew moves, that is into or out of the cork, then the north magnetic pole will be seen to turn in the direction in which the corkscrew turns. I give you these three rules because it is very easy to choose one of them and fix upon it, but you are apt to get confused if you do not fix on the one which you are going to use for the future. I recommend each one who has not a rule of his own for the purpose, to fix on one of these and keep to it as to the direction in which the compass needle moves. Then when you want to know in which direction the current moves, you always have to remember that by the law that action and re-action are always equal and opposite, therefore, under these circumstances, if the north pole tends to move in one direction, you know that under the same circumstances the current tends to move in the opposite direction.

Now I must come to another set of phenomena; the action of a coil on a piece of iron is to magnetise it, and this action tends to make that magnet move. In fact, the action of this coil is to create a magnetic field. The action of the coil is identical with the action of a magnet. The magnet could be constructed of definite proportions which could behave in exactly the same way as this coil does on all external objects. I do not say on objects in the interior of it, because there there would be a difference, but on the exterior object. If the action of this coil and the magnet which could be made would be identical. Now if this coil attracts the magnet, and another coil will act as a magnet it is perfectly clear the two coils ought to attract each other. Each of these coils before you is acting as a magnet, and, therefore, they ought to be able to attract each other, or to repel each other according to the position of their axes, and according to the direction in which the currents are rotating around the coils of wire. This is a part of the development of those grand researches which were undertaken by the French philosopher, Ampère. Ampère thought there ought to be some action between conductors which carry currents of electricity, and on studying these actions he was able to bring out some general laws. He aimed at putting his conclusions in a certain definite form. He supposes we have two circuits, whether they are coils, or whatever they may be, with electric currents, each little bit of a current in the one circuit was acting with some force or another upon each little bit of a current in the other circuit, and that the total action observed was the sum total of all these little independent actions. This was a very difficult way of attacking the problem. He did attack it from a purely mathematical point of view, and worked it out mathematically to find what law it would be necessary to assume in the action between little pieces of current in order that all the phenomena which are observed might supervene. One result he showed to be that two little bits of current parallel to each other either attracted each other or repelled each other according as the directions of the currents in the two were the same or opposite. I have the means there of showing you this by means of a flat coil of wire. The wire was simply wrapped between two boards, the wire being insulated and wound round itself constantly, always being coiled between two boards until we get a flat spiral of considerable size, and exposing a considerable surface, which might be subjected to an attracting or repelling influence. The suspension of the the coil is effected by means of the wire itself; the two ends of the coil are continued up to the beam over my head, and thence wires go to the battery, so that I am able to send a current circulating through that coil. I have here another coil or flat spiral, exactly similar to the one I have been describing. I have a battery also attached to this spiral, and a separate battery attached to the other spiral. The current is now circulating through the suspended coil, but there is no current at present circulating through the coil I hold in my hand. I bring this coil in the neighbourhood of the suspended spiral, and there is no motion whatever, whether I hold one side towards it or the other. Now if we put on the current, you will see immediately an attraction. It draws the other spiral to it, and tries to stick to it; on breaking the contact it flies away immediately. Here, then, is a case in which the two currents of electricity were circulating round these two coils in the same direction, and the parallel currents, going in the same direction, attract each other. Now we will reverse the direction of the current of electricity, so that the currents in the two coils will be going in opposite directions. I am now holding my coil close to the suspended one, and there is a violent repulsion when I bring the coils close together; they try to slide over each other, and get away from each other. I could get up quite a swing by following it about a little time, and I can check the swing by a judicious movement of the one I hold in my hand. I will now simply turn my coil round, and ask Mr. Davenport to put on the current in the same direction in which he had it just now, and there is immediate attraction. So that you see when I reverse the position of the coil, I am doing exactly the same as if I had reversed the direction of the current by the commutator. We have attraction when the one current is circulating in the same direction, just as we always found that we had attraction when the current of electricity was rotating in the same direction in the two spirals.

I will now show you by means of a piece of apparatus on the table, the truth of Ampère's conclusions, viz., that two parallel currents attract each other when they are going in the same direction, and repel each other when they are going in opposite directions. This piece of apparatus consists of a vertical column supporting at its top, on a pivot, a horizontal wire, which is then bent downwards, and dips into a trough of mercury, the base of the vertical column. I shall be able to put on a current immediately, and the direction of the current I have carefully observed before. The current is coming from the copper and going to the zinc of the battery, and goes up through this part of the external circuit. The current of electricity in the wire which I hold in my hand is also going in the direction of the arrow which is attached to the conductor I hold in my hand. The currents are now circulating in this direction. In the first place I will keep both currents in the same direction. As I bring mine near the suspended one, you immediately see an attraction producing a rotation of the whole apparatus round the central pivot. I reverse the action by bringing it the other side, the two currents being parallel, and there is the same attraction, showing that two parallel currents going in the same direction attract each other. I will now steady it, and hold my current in the opposite direction with the point of the arrow downwards, and cause the current to flow downwards whilst that in the apparatus goes upwards; bringing them near to each other we shall see there is a decided repulsion. These two main principles of Ampère's experiment appear to be true, viz., that two parallel currents attract or repel each other according as the direction of the currents are in the same or opposite directions.

There is another part of Ampère's conclusions to which I would also direct your attention. He also showed us that if two wires both carry currents, and cross each other, and if they can rotate about the point of intersection, then if the currents are going both to or both from the point of intersection, we have attraction. If one is going to and the other from the point of intersection, we have repulsion. I have an apparatus here which will show this action very well. This is a beautiful piece of apparatus which I happened to come across the other day. I daresay it is very common, but I never saw it before. There are two coils of wire, both on vertical pivots, and both capable of rotating about that axis. A current of electricity can be independently sent through these two wires. Both of them in rotating are able to make contact with mercury, which is contained in little cups. The ends of the one coil always dip into the same cups of mercury, and therefore the current always goes in the same direction through that coil. The ends of the other coil dip into a cup which has a partition, and the mercury which is in the cup rises by capillary force above that partition so as to meet; and thus we have two mercury sectors into which the wires can dip, and this acts as a commutator tending continually to reverse the direction of the current; so we shall find that there is attraction tending to bring the currents together up to a certain point. As soon as that point is reached the current is reversed, and then the force is converted into repulsion, tending to continue the rotation. By this ingenious device we can get continuous rotation of these two coils round the vertical axis of two coils rotating in opposite directions. That illustrates the action I have just been describing, showing the attraction or repulsion between these two cross conductors at the top and at the bottom of the pivot, combined with the attraction of parallel conductors which are at the sides, and it forms a very pretty illustration of the principle.

In conclusion, I will show you an experiment which further illustrates the attraction of currents for each other in a very simple way. I have upon the stand a spiral of copper wire forming a vertical coil freely suspended from its top. The lower end of the copper wire dips into a small vessel of mercury. Now when I turn on the current we know that there will be attraction between each one of those spirals and its neighbour, and the attraction is simply due to the creation of a magnetic field in the way in which we have evolved these things from Oersted's experiment. By the creation of a magnetic field there is an attraction produced between the turns of spirals. If I were to put a piece of iron into the centre of it, the intensity of the magnetic field would be increased, but even without that there is a magnetic field created there producing attraction between the spirals of this copper wire. The result is to lift the point right out of the mercury, so that if a current of electricity has passed through the spiral and lifts the spiral above the mercury the current of electricity would be stopped as soon as this action has commenced to take place. Immediately then, the current having ceased, the spiral resumes its normal length, and sinks again into the mercury. Then the current acts again, a magnetic field is created, the attraction ensues, and it is lifted out of the mercury again, so that in that way it is alternately lifted and dropped at a very rapid rate. The sparkling indicates the change, and you can also hear it. I want you to notice the rapidity with which the sparkling takes places which makes the action perfectly evident.

General Notes.

Manganese in Russia.—From an official report lately issued it appears that the production of manganese in Russia is steadily increasing. The exports for the first four months of this year amounted to 9,000 tons, as against 4,500 tons for the corresponding period of 1885. This is shipped principally from Poti, where it is conveyed by the Transcaucasian Railway from the mines. in order not to interfere with the petroleum trade of the neighbouring port of Batoum. Owing to the bad condition of the conveyance used in transporting it from the mines at Tchiatoor to the Transcaucasian Railway, large lumps of ore only can be carried, the result being that the smaller pieces, which are equal to two-thirds of the total quantity extracted, are wasted, although equal in quality to that exported.

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CANTOR LECTURES.

THE MICROSCOPE.

By John Mayall, Jun.

Lecture IV.—Delivered December 14, 1885.

MODERN MICROSCOPES TO THE DATE OF THE APPLICATION OF ACHROMATISM (CONTINUED).

Martin's "Pocket Reflecting Microscope."—This microscope (Fig. 53, p. 1056) was figured in B. Martin's "Micrographia nova" (Reading, 1742, 4to). The point of interest is the application of a screw-micrometer in the eye-piece, having a certain number of threads to the inch, by which accurate measurements could be made. Martin was, I believe, the first to provide accurate means of determining the exact magnifying power of any object-lens, so that the observer might state definitely that he used an amplification of a certain number of diameters. He describes his method thus:—

> "Take any Ruler, &c., which has inches divided into *Tenths*, and place it under the Microscope so that you may have one of these Tenths in full View in the Image, then measure it carefully with the Micrometer, and count how many turns were made in so doing; divide that number by 5, and the Quotient will show how many times the Image is bigger than the Object. Thus suppose in Measuring one of those Tenths I make 40 Turns, that divided by 5 quotes 8; and so many times does the Microscope magnify with the glass. *Note*, the Reason why you divide by 5, is because there being 50 Threads to an Inch, 5 must be equal to one Tenth in the Object; therefore as many times 5 as there are in the Image, so many times must the Object be magnified" (pp. 12-3).

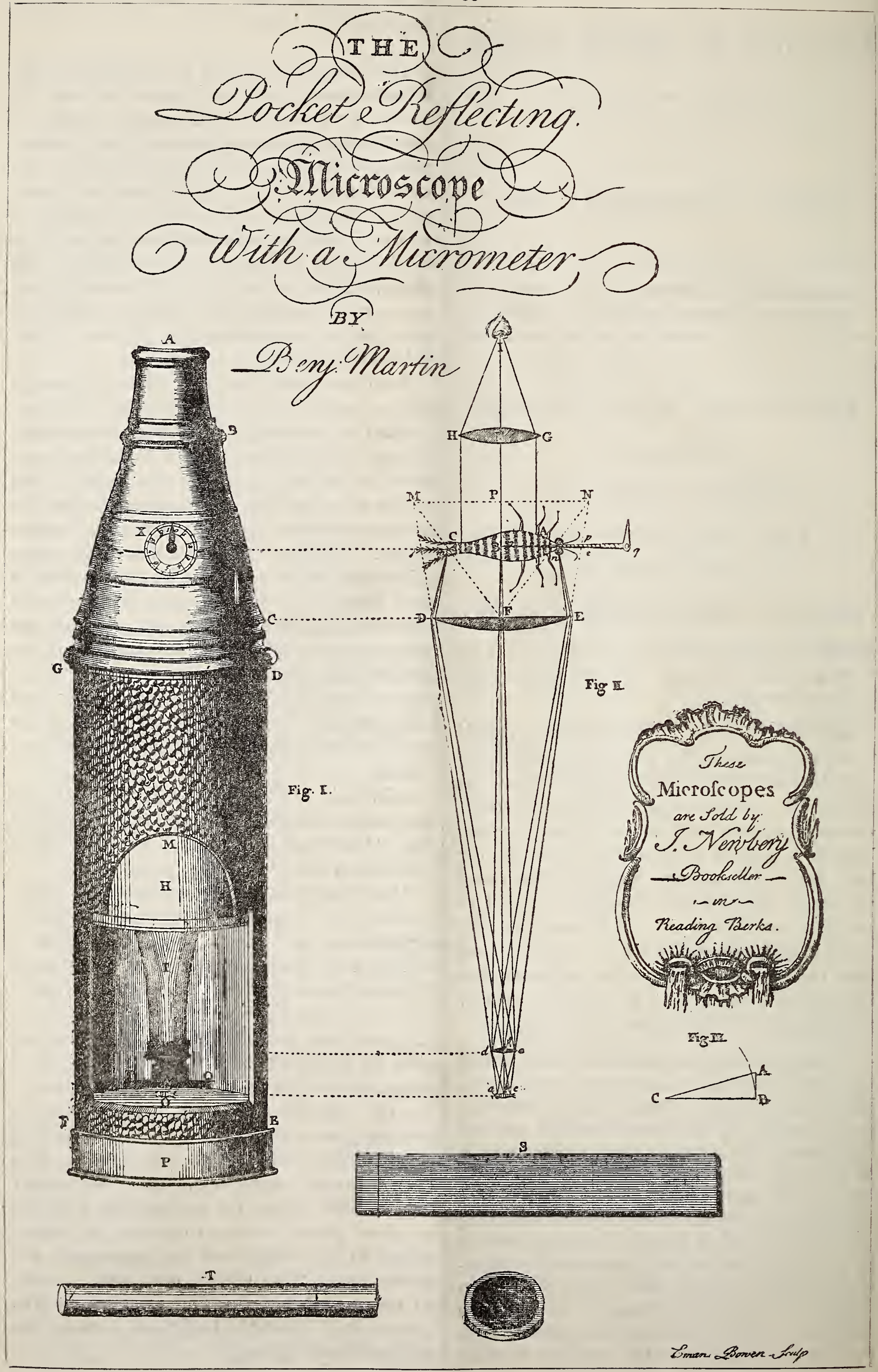
This instrument had a mirror fitted in the cylinder-base, and was hence termed by Martin a "reflecting" microscope, though, in fact, it was a compound dioptric form. Martin regarded the base as a special point in the construction "for the instrument to stand upon." In later constructions the tubes were of brass, and the outer one was cut away to facilitate the placing of object-slides on the stage, and the mirror was hinged exactly as we see in the "Microscope à tambour," which is now largely manufactured in Paris as a low-priced instrument.

I do not think that any other microscope has a better claim than this one to be regarded as the original form of the modern "drum" microscopes, which Frauenhofer revived in the early years of this century, and which was modified by Oberhaeuser into his well-known form of dissecting compound microscope. This latter has gone through a series of alterations—conducted with admirable skill and foresight by Oberhaeuser, Hartnack and Prazmowski, Zeiss, Nachet, sen., and his son and successor, Alfred Nachet—resulting in the general type of microscope known as the "Continental model," with which I believe it is no exaggeration to say that 90 per cent. of the useful microscopy of our time has been produced.

Martin's "Universal Microscope."—In the same work Martin figured and described his "Universal Microscope, mounted on a Ball and Socket" (Fig. 54, p. 1057).

Martin appears to have considered his application of the ball-and-socket as of prime importance, and he introduces it with a criticism on the inconvenience of the "usual Construction of the large double Microscope," of the tall tripod form, referring, doubtless, to Culpeper and Scarlet's model. He claims that with his ball-joint one can "view all Kinds of Objects in every possible Position or Situation" (p. 13). No fine adjustment was applied; the focussing was effected (presumably) by sliding the body-tube within the sheath, D E. The "Quadrantal" stage, R Q, moved horizontally on the pillar, P, and the zone-section, V U, was of glass placed over an opening of similar shape in the stage and concentric with the pillar, hence "the Object, once well posited, is not moved, but the Plate whereon it lyes passes thro' the whole Length of it under the Object Glass" (p. 15).

Fig. 53.



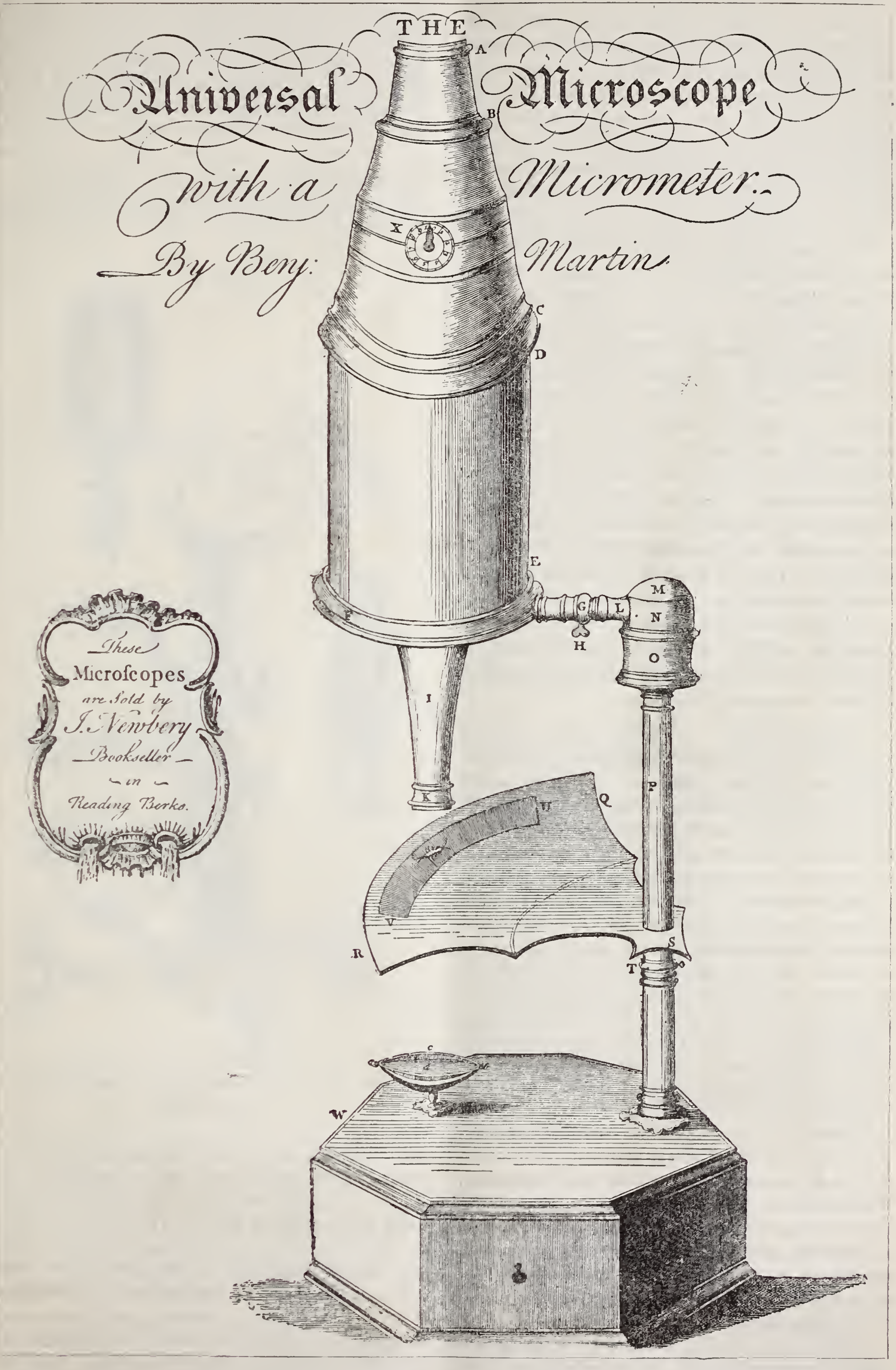
THE
Pocket Reflecting
Microscope
With a Micrometer
BY
Benj. Martin

These
Microſcopes
are Sold by
J. Newbery
Bookseller
in
Reading Berks.

Eman Bowen sculp

(1742).

FIG. 54.


THE
Universal Microscope
with a Micrometer.
By Benj: Martin
These Microscopes are sold by J. Newbery Bookseller in Reading Berks.
A
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(1742).

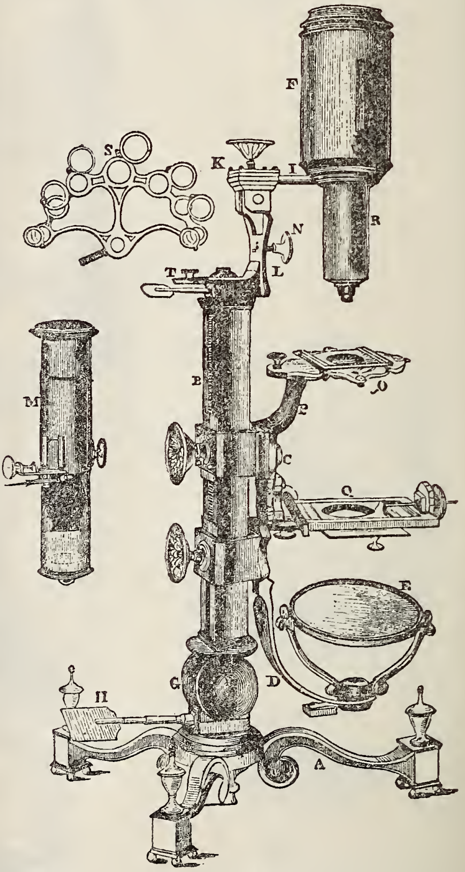
Martin devised numerous improvements in the mechanism and optical arrangement of the microscope. He appears to have suggested the rotating multiple lens-carrier nosepiece, in which he placed six different powers to rotate successively in the axis, first applied to a simple microscope and later to a compound. The invention of the multiple system of pocket lenses is attributed to him. He applied to a simple microscope a fine adjustment (after Cuff's design, but acting on the stage—not on the optical body, with "the constant pressure of a Spring" to check the motion—(*vide* "Optical Essays," p. 9, Fig. XVI.). He also applied to simple and compound microscopes rack-and-pinion focussing adjustments; to the latter he added inclining movements to the pillar carrying the stage and mirror, and rectangular mechanical motions to the stage.

Martin's Large Universal Microscope.—This instrument (Fig. 55) was formerly in the possession of the late Professor Quekett, who presented it to the Microscopical Society of London. After a general reference to "the extent and variety of its accessory instruments . . . ." in which "it is perhaps one of the most complete instruments ever manufactured in this or any other country," Quekett describes the microscope as follows:—

"This microscope . . . . stands about two feet in height, and is supported on a tripod base, A; the central part or stem, B, is of triangular figure, having a rack at the back, upon which the stage, O, and frame, D, supporting the mirror, E, are capable of being moved up or down. The compound body, F, is three inches in diameter; it is composed of two tubes, the inner of which contains the eye-piece, and can be raised or depressed by rack and pinion, so as to increase or diminish the magnifying power. At the base of the triangular bar is a cradle joint, G, by which the instrument can be inclined by turning the screw-head, H [connected with an endless screw acting upon a worm-wheel]. The arm, I, supporting the compound body, is supplied with a rack and pinion, K, by which it can be moved backwards and forwards, and a joint is placed below it, upon which the body can be turned into a horizontal position; another bar carrying a stage and mirror, can be attached by the screw, L N, so as to convert it into a horizontal microscope. The stage, O, is provided with all the usual apparatus for clamping objects, and a condenser can be applied to its under surface; the stage itself may be removed, the arm, P, supporting it, turned round on the pivot C, and another stage of exquisite workmanship placed in its stead, the under surface of which is shown at Q.

"This stage is strictly a micrometer one, having rectangular movements and a fine adjustment; the movements being accomplished by fine-threaded screws, the milled heads of which are graduated. The mirror, E, is a double one, and can be raised or depressed by rack and pinion; it is also capable of removal, and an apparatus for holding large opaque objects, such as minerals, can be substituted for it. The accessory instruments are very numerous, and amongst the more remarkable may be mentioned a tube, M, containing a speculum, which can take the place of the tube, R, and so form a reflecting microscope. The apparatus for holding animalcules or other live objects, which is represented at S, as well as a plate of glass 6 inches in diameter, with four concave wells ground in it, can be applied to the stage; so that each well may be brought in succession under the magnifying power. The lenses belonging to this microscope are twenty-four in number; they vary in focal length from 4 inches to 1-10th of an inch; ten of them are supplied with Lieberkühns. A small arm, capable of carrying single lenses, can be applied at T, and when turned over the stage, the instrument becomes a single microscope; there are four lenses suitable for this purpose, their focal length

Fig. 55.



Martin's Large Universal Microscope (*ante* 1782).

varying from 1-10th to 1-40th of an inch. The performance of all the lenses is excellent, and no pains appear to have been spared in their construction. There are numerous other pieces of accessory apparatus, all remarkable for the beauty of their workmanship." ("A Practical Treatise on the Use of the Microscope," 3rd ed., London, 1855, 8vo., pp. 25-6).

In addition to the movements described above by Quekett, the body-tube, with its support, can be moved in an arc concentrically with the axis of the triangular pillar, H, on the top of which it is fitted with worm-wheel and endless-screw mechanism, actuated by the screw-head below T.

Though I cannot endorse Quekett's criticism on this instrument, namely, that "in point of workmanship" it "can probably not be surpassed, even in the present day," not even with reference to the workmanship of his day, for microscopes by Powell, Ross, Pritchard, Charles Chevalier, and Smith and Beck, were then constructed which were superior in every essential point of workmanship; yet I must admit that Martin led the way far beyond his contemporaries, both in the design and the execution of this microscope. From my point of view, any detailed comparison of the design with that of our best modern microscopes would lead to such a disparagement of Martin's *chef-d'œuvre*, that I prefer not engaging upon the task.

I cannot, however, pass over Martin's work in connection with the microscope without calling attention to the fact that he was the first to construct an achromatic objective, and at a date so early in the history of the application of achromatism that his priority as a mere question of date cannot be disputed. In his "New Elements of Optics" (London, 1759, 8vo), published in the year following Dollond's communication to the Royal Society of his successfnl construction of an achromatic telescope (1758), Martin dealt with the principle of achromatism, and after stating the results of his comparisons of achromatic telescope object-glasses with reflecting telescopes of the same magnifying power, in which he gave the preference to the latter, he informs us that he made a similar comparison between an achromatic object-glass and a speculum, applied as an object-glass in a compound microscope. He thus describes his experiment: —

> "Having found so great a Difference in the Appearance of Images formed in the solar Focus of a compound [achromatic] Lens and Speculum, I thought it would be necessary to compare the Appearance of the Images form'd in the proper or conjugate Focusses of a small triple [achromatic] Lens and Speculum, applied as an Object-Glass in a compound Microscope, ... which I did by giving the same Length to the Images, and viewing them with the same Eye-Glasses; and consequently the small Objects were equally magnified in the refracting and reflecting Microscope, but with how great a Difference in point of Clearness and Perfection in all the Circumstances of Vision, those only will be able to conceive who shall try the Experiment themselves" (p. 96.)

Martin states that he made similar comparisons between "a double *achromatic* Lens, and a Speculum of the same focal distances" applied to a *Camera Obscura*, and also as "Solar Megaloscopes," and in each case the advantage was with the speculum.

When we consider the severity of the tests he applied, and that even now there are astronomers who prefer the reflecting to the refracting telescope, we need not be surprised that Martin's achromatic microscope objective should have proved in his hands inferior to the reflecting microscope. The case could hardly have been otherwise, for reflectors up to a moderate size were nearly as well made then as they can be made now; but the construction of achromatic objectives for the telescope, microscope, &c., was a quite new art, involving enormous extra difficulties of workmanship at that date. If we were to test some of our inferior 1 inch or 1-2 inch achromatic objectives against some of Cuthbert's reflectors of the same magnifying power, I suspect we should have to endorse Martin's judgment in favour of the reflectors.

But the question I have in view is—Whether or not we shall be justified in assigning to Martin the credit of the first production of an achromatic microscope-objective?

By his own admission he made one, and we know that he published the fact in 1759, for the publication is before us. That he did not succeed in such a manner as to induce him to adopt the achromatic system to the exclusion of the older systems is a difficulty I admit; it shows, at any rate, that he did not fully appreciate the value of achromatism in microscope-objectives. If he had sent his achromatic objective to the Royal Society instead of publishing the result of his comparison of it with a reflector (as cited above), there can be no doubt he would have had full recognition as the inventor of achromatic microscopes, quite regardless of the mere quality of his work.

If the criterion of invention be the *first* *construction* combined with *first publication*, then Martin must be regarded as the inventor of the achromatic microscope.

Cuff's Compound Microscope.—This microscope (Fig. 56, p. 1061) was figured and described by Baker (" Employment for the Microscope," 1753, 8vo, pp. 442-6) who considered it more serviceable as a working instrument than the tall tripod form of Culpeper and Scarlet. The stage was more accessible, while the application of a fine adjustment of greater delicacy than any previously in vogue shows that Cuff aimed distinctly at improving the mechanical construction. The slotted tube, I, carries a polished reflector, *h*, at the lower end, and is adjustable on the lower part of the body-tube for illuminating opaque objects. R is a conical diaphragm fitting beneath the stage. Q is a Lieberkühn lens.

Soon after the publication of this model, Adams and others improved upon it by applying a cradle-joint to the lower end of the pillar, on which the instrument could be inclined; the mirror was then attached to the pillar, first by a horizontal rod passing through it, and connected with the gimbal, and then, with the addition of an arm, giving lateral swing. I believe Martin was the first to apply a separate stem, of square section, on which the mirror could be slid up or down; then he made the mirror travel by rack-and-pinion on the standard itself, as we saw on his large Universal Microscope.

Nairne made Cuff's microscope in a very substantial manner, fitting it on a cradle-joint to shut down in a box; and he was one of the first makers of compound microscopes to plan the instrument with a view to portability. Other opticians, both here and abroad, worked out various plans for rendering this microscope portable, such as by screwing the pillar within a box; but Nairne was the most successful, for his plan did not diminish the general stability of the instrument. Passemant, of Paris, copied Cuff's model exactly, in some cases gilding the metal work throughout; he also added ornamental scrolls, &c., in one example I have seen, these ornaments were carried to the verge of absurdity—a not uncommon defect in the designs of microscopes, &c., in France during the last century.

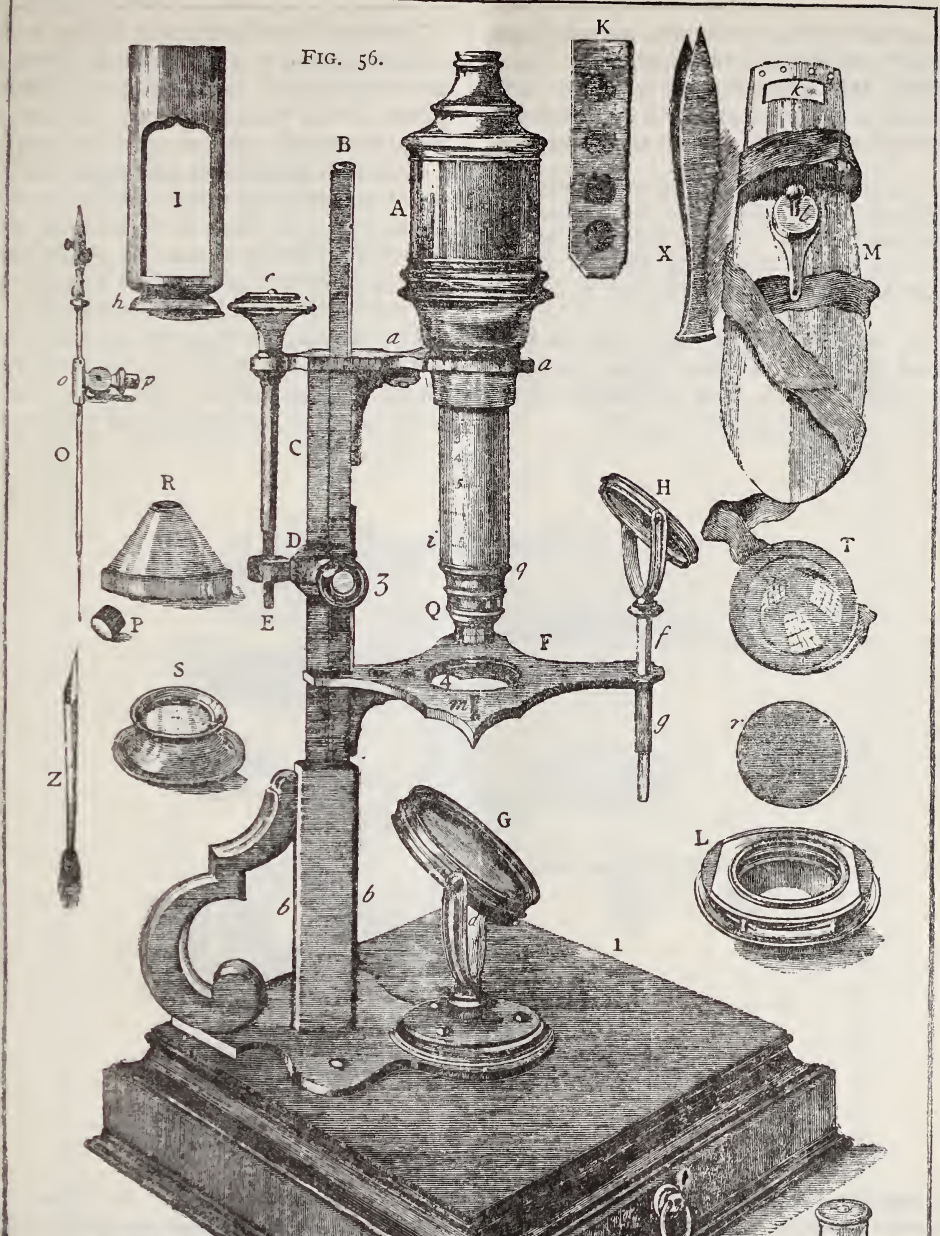
Baker states that in 1747 Cuff contrived a micrometer for his microscope, consisting of a "Lattice of fine Wires," distant from each other 1-50th of an inch, and intersecting at right angles; this was placed in the focus of the eye-lens so as to "divide the whole visible Area of the Microscope into Squares, whose Sides are each 1-50th of an inch" (*vide* description by Martin Folkes, P.R.S., *ib.*, p. 426).

Folkes mentions that he had been informed that " silver wire may be had to make these lattices of, whose diameter is rather less than the seven hundredth part of an inch " (*ib.*, p. 430).

Ellis's "Aquatic Microscope" (made by Cuff).—In Ellis's "Essay towards a natural History of Corallines" (Lond., 1755), this microscope (Fig. 57, p. 1062) is figured. We have here the model which we may safely regard as the original from which our best forms of simple dissecting microscopes have been developed. A disc of plane glass, C, or a concave, M, was applied on the stage on which dissections, &c., could be made; a mirror, I, was fitted in a gimbal with a stem sliding in a socket in the pillar; the lens-carrier, F, alone, or with Lieberkühn, F, screwed in a ring on the end of a horizontal arm, E, sliding through a socket, attached to a vertical rod, D, sliding and rotating in a socket at the back of the pillar for focussing, &c. The pillar screwed on the lid of the box, within which the instrument was packed with sundry accessories.

About 1835, Raspail was connected with a modified form of this microscope which became very popular in France; the horizontal arm was made to move forward or backward by means of an internal screw controlled by a milled head at the back, and these movements, together with the rotation in the vertical socket, enabled the observer to view different portions of the object in a manner equivalent to the use of mechanical movements of the stage. The success of Raspail's model roused much jealousy among the opticians in Paris. Vincent and Charles Chevalier, then regarded as the leading manufacturers, took especial umbrage at certain laudatory notices of the "new" microscope, and the latter addressed (April, 1835) a communication of "Notes justificatives" to the "Académie Royale des Sciences," characterising the model as a mere plagiarism on Cuff's (Ellis's). Shortly afterwards, however, C. Chevalier proceeded to modify the instrument, improving it both optically and mechanically; but, notwithstanding his efforts to disconnect Raspail's name from the design, it is still best known as the "modèle Raspail," and Chevalier's improvements have been almost wholly ignored. Andrew Ross applied a fine adjustment to his modification of this model.

FIG. 56.



J. Parbury delin.

J. Tinney sculp.

A new constructed Double Microscope, as made & sold by the Inventor JOHN CUFF *in Fleet ſtreet London.*

Published according to Act of Parliament September 20th 1744

Adams's "New Universal Single Microscope."—In Adams's "Microgr. illustr." (cited above), this microscope (Fig. 58, p. 1063) appears as the frontispiece. He introduces his description of the instrument as follows :—

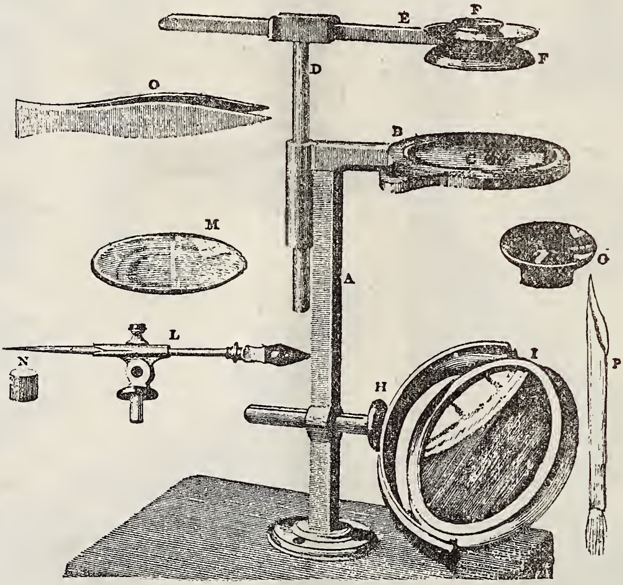
> "It hath long been the Desire of the Curious and Inquisitive Part of Mankind, to have a Microscope which would be Portable and Universal, that is to say, One only *Instrument*, by which all Sorts of minute Objects might be observ'd" (p. 1).

He tells us "This Microscope is made either of *Brass* or *Silver*, and is composed of *six* double convex *Lens* of different Foci" (*ib.*).

The disc, M M M, containing the six lenses, could be rotated in a collar-fitting on the top of the pillar, so as to bring the different powers to bear upon the object. N is an eye-guard connected with the top of the pillar by a short arm, under which the lenses pass. O is a "reflecting Speculum of Silver, or other Metal, highly polished; which when an opake Object is to be viewed, must be placed under the Eye-piece N" (p. 2). This reflector was not yet (1746) termed a "Lieberkühn."

The mirror, F, is supported by a hinge, V, in the centre of the back, on a short pillar, H, rotating in the disc, G. The feet, A and B, pivot on C, and fold under D for convenience of packing. A fine adjustment screw passes through the pillar, and is actuated by a milled head, P, and connected with the stage. Adams remarks that "the screw P is to be turned as your hands and arms are resting upon the table, which is a conveniency to be met with in no other Microscope" (p. 5).

Fig. 57.



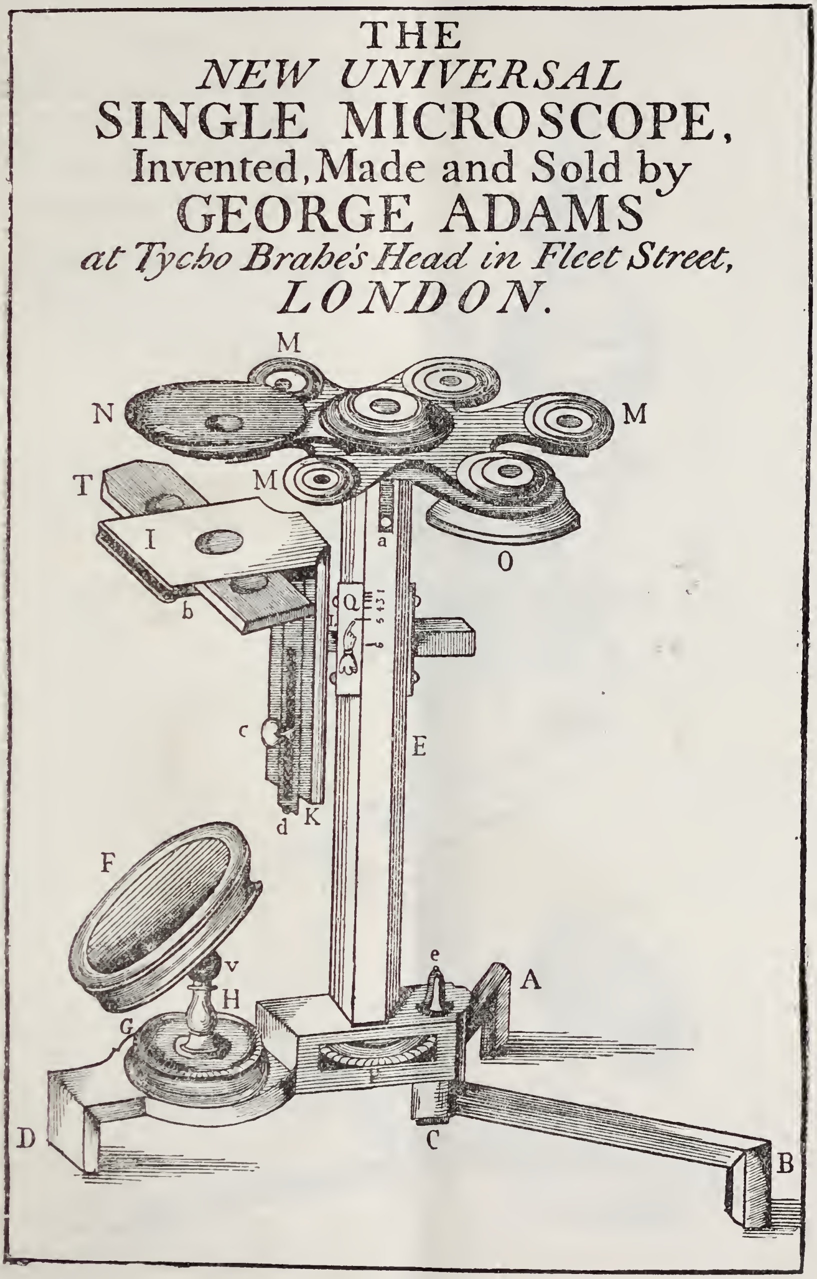
Ellis's "Aquatic Microscope" (1755).

The numbers engraved on the pillar "shew the respective Distances of the Object from the Magnifiers, according as each Glass magnifies more or less. For instance, if you use the 5th magnifier, first place it under the Eye-Piece N, and then with your Finger and Thumb turn the Screw P, till the Finger of the Hand which is engraved on the Sliding-piece Q, points to the Mark 5 on the Pillar; then will the Object be very near its exact Distance from the Magnifier; so that by a Turn or two of the Screw P, either backwards or forwards, to be found by trial, you may soon fit it exactly to your Eye" (pp. 2-3).

The combination of this instrument with a heliostat, forming a solar microscope, was shown in Fig. 51. The connection was made by removing the mirror, F (Fig. 58), and the disc, G, from the front foot; then the microscope was placed horizontally, and the conical-ended tube, forming a draw-tube to the solar apparatus, was screwed in the place of G, through the under side of the foot.

In practice, as a simple microscope, this large disc lens-carrier is very inconvenient; in order to apply the eye close to the eye-guard, one is obliged to turn the head awkwardly. The instrument is so light that one is obliged to hold it firmly with one hand whilst actuating the fine adjustment with the other hand—not a commendable arrangement.

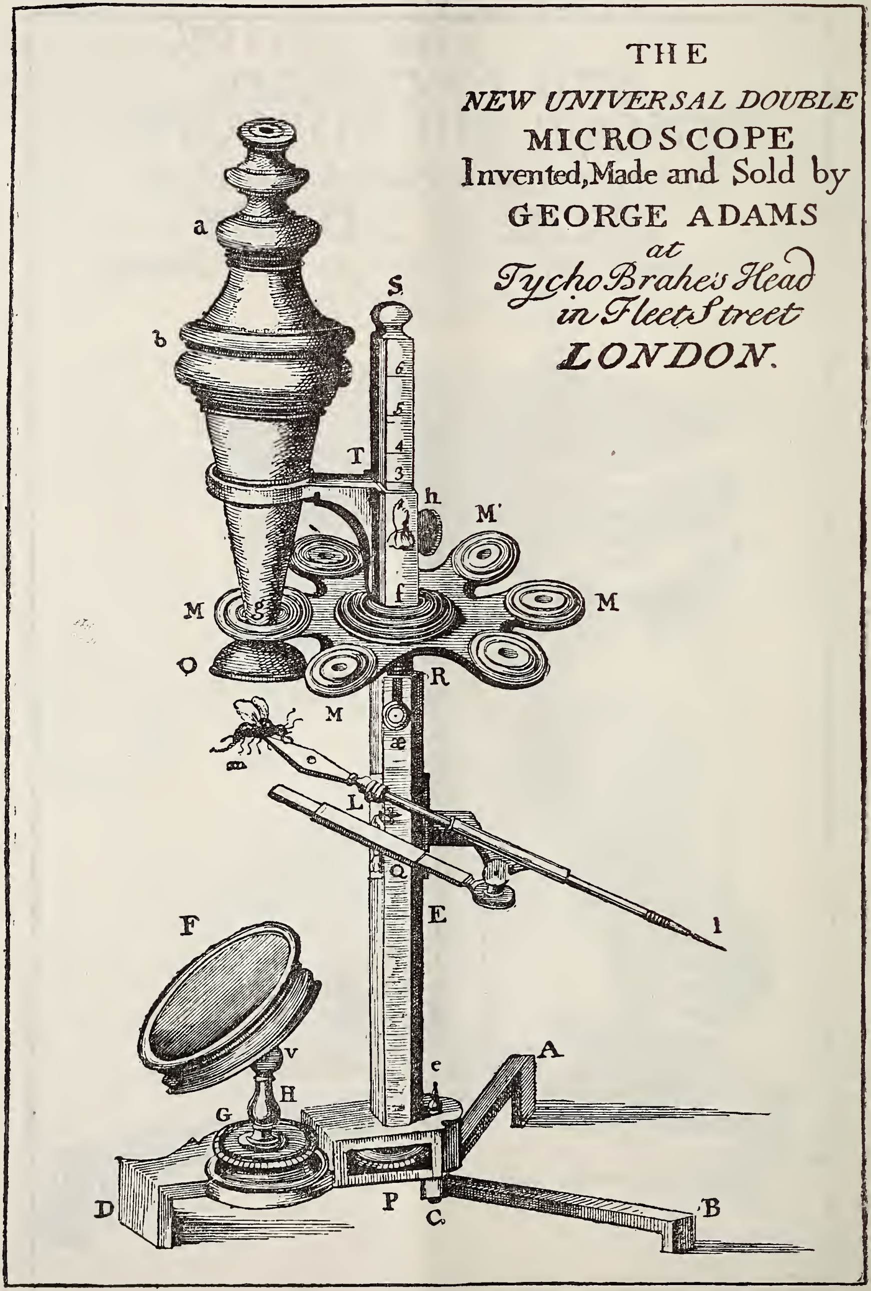
Fig. 58.



(1746.)

Adams's "New Universal Double Microscope."—In the same work, Pl. III., we find this microscope (Fig. 59, p. 1064). The hexagonal pillar of the instrument, shown in Fig. 58, is here continued above the disc, MMMM, of lens-carriers, by a pillar of square section, RS, attached by the screw, *æ*: the disc rotates as before in the collar-fitting, F, which is connected with a sliding socket (moving on RS) having an arm, T, and ring to support the

Fig. 59.



(1746).

compound body-tube. The focus was adjusted roughly by sliding the socket to the numbers on the pillar corresponding with the powers, and then the fine adjustment screw, P, acted on the object-carrier, U, as in Fig. 58.

No stage is shown in the Figures, but in the instruments I have examined, the stage was applied by means of a short stem at the back fitting in a hole, L, in the pillar, E (Fig. 58).

Adams explains how "these two new microscopes are best illuminated by Candle-Light," using a globe of water as a condenser, "and if that should prove too glaring, as it sometimes does, interpose between the globe and microscope a piece of thin oil'd paper, by which means most sorts of objects may be view'd as well by night, as in the day time" (*ib.*, p. 7), which plan was equivalent to that of Hooke, as used with sunlight.

Adams's "Variable Microscope."—In the 4th ed. (1771) of Adams's "Micrgr. illustr." this microscope (Fig. 60, p. 1066) is figured and described (pp. i-vi. Pl. II). Adams states that "We owe the construction of the variable microscope to the ingenuity and generosity of a noble person. The apparatus belonging to it is more convenient, more certain, and more extensive than that of any other at present extant; consequently the advantage and pleasure attending the observations in viewing objects through it, must be as extensive in proportion."

In this instrument Adams claims to have embodied a number of improvements on all previous constructions. He applied "two eye-glasses at A, a third near B, and a fourth in the conical part between B and C," by which he increased "the field of view and of light;" draw-tubes were at A and B, by which these lenses could be separated more or less. He also arranged the object-lenses, or "buttons," A and B, to be combined; seven "buttons" were provided, "also six silver specula ["Lieberkühns"] highly polished, each having a magnifier adapted to the focus of its concavity, one of which is represented at E," and the "buttons" could also be used with "any-one of these specula," by means of the adapter, D.

The body-tube, A B C, with its arm, F (in which it screwed at *f*), and stem attachment with the fine adjustment, were clearly modified from Cuff's design (Fig. 56). The large ivory head, I, actuated a pinion and rack for raising or depressing the body-attachment on the stem. The stage and mirror were adjustable on the stem. The large ratchet-wheel controlled by the pinion-handle, S, gave the required inclination to the stem.

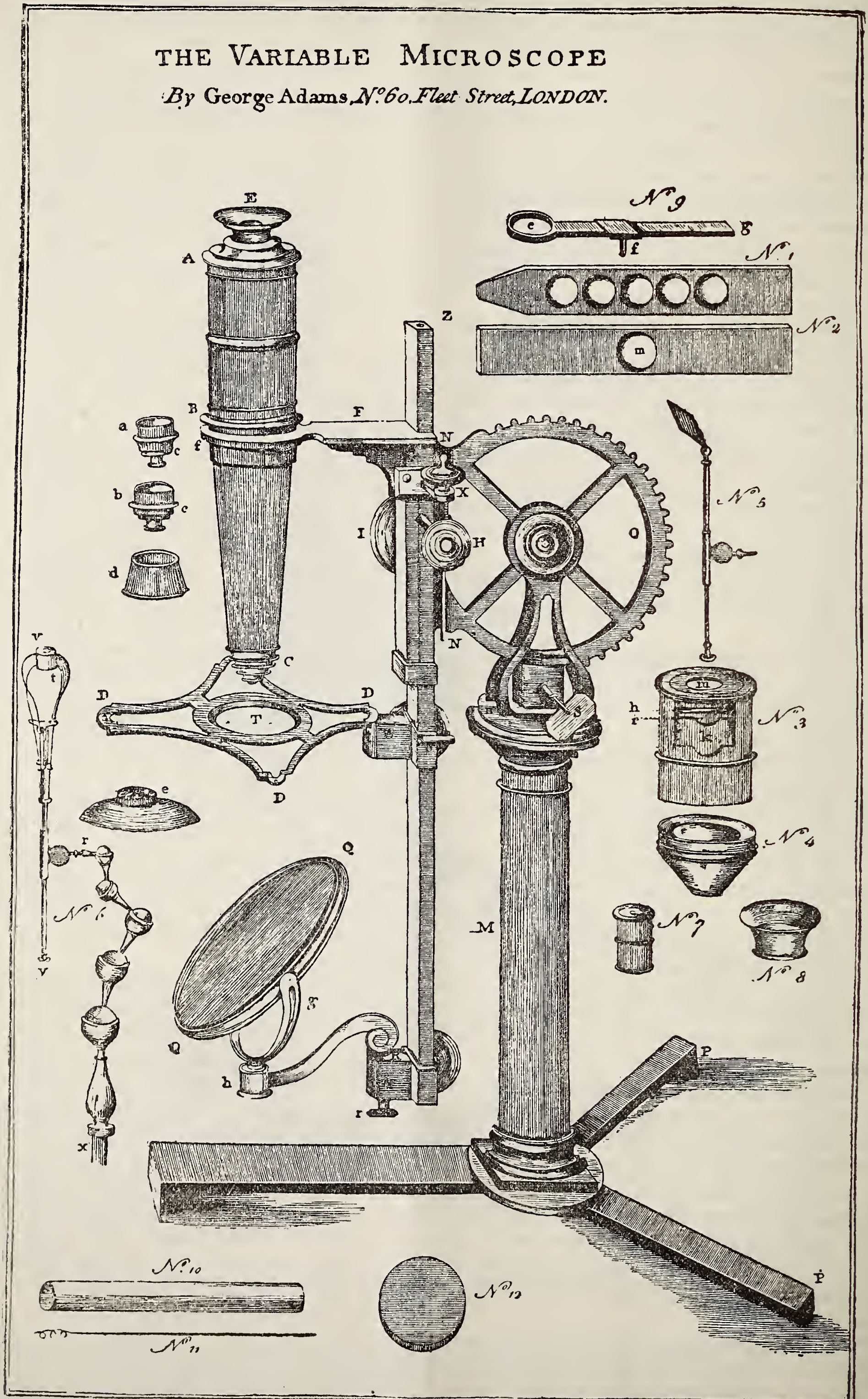
Nos. 1 and 2 were ivory and glass "sliders" for objects, to be applied in the spring-stage No. 3 fitting at T; the "hollow at K [No. 3] is to receive the glass tube No. 10." No. 4 was a diaphragm fitting in the lower end of No. 3, "to exclude some part of the light which is reflected from the mirror Q." The forceps, No. 5, could be placed "in one of the small holes near the extremities of the stage, or in the socket R, at the end of the chain of balls No. 6." No. 6 was an arm composed of a series of ball-and-socket joints, similar to the system employed by Musschenbroek (Fig. 28), by Joblot, and by Lyonet, to which I referred in my remarks on Joblot's microscope, and was intended to be applied at W, when the stage was removed. No. 7 was a box of ivory in which discs of talc, and brass rings were packed; No. 8, a hand-magnifier; No. 9, a sliding arm lens-carrier fitting on Z, when the instrument was required to be used as a simple microscope; No. 11, a rod of wire with spiral at the end for picking up soft objects from bottles, &c.; and No. 12, an ivory disc, black on one side and white on the other, fitting at T to carry opaque objects.

To use the instrument as a simple microscope, the body-tube, A B C, was removed from the ring, F; the lens-carrier, No. 9, was placed on Z, and a lens with reflector, E, screwed in the ring, C; the ball-and-socket arm, No. 6, was applied at W, by the part X, and the object held by either of the forceps could be turned and viewed as desired. For dissections, &c., the stage could be screwed on at F, and a glass plate applied at T.

One of the best examples of this design that I have seen, has a nose-piece with a slide carrying three objectives—the first arrangement of "triple nose-piece," or, indeed, of changing nose-piece for objectives (as distinguished from simple lens-carriers), that I have met with.

The inclining movements that were applied previous to the date of this instrument were generally defective. The ball-and-socket as employed with large microscopes by Hooke, Marshall, and Martin, could never have been a really serviceable arrangement; the cradle-joint at the lower end of the pillar, as employed by Cuff, Adams, and Martin, though better than the ball-and-socket, could not have been quite satisfactory. In the "Variable Microscope" Adams made a new departure as regards the mechanism of the inclining movement, by placing it far more under control than any previous system. Were we disposed to criticise this mechanism, we might easily show that Adams here applied an extremely complex system to arrive at a minor result, and that he passed over feeble points in

Fig. 60.


THE VARIABLE MICROSCOPE
By George Adams, N.º 60. Fleet Street, LONDON.
E
A
B
a
c
f
b
c
d
N.º 9
e
f
g
N.º 1
N.º 2
m
Z
F
N
X
I
H
O
N
N.º 5
C
D
T
D
D
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V
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N.º 6
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x
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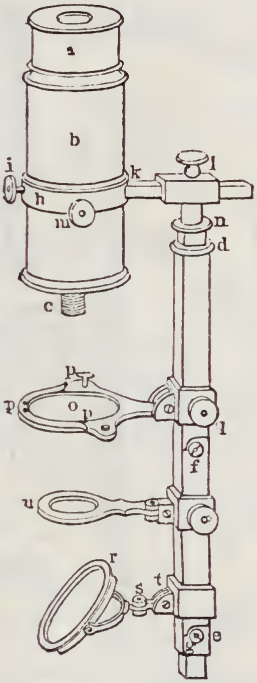
Q
M
g
Q
h
r
P
P
N.º 10
N.º 11
N.º 12

(1771).

his design apparently oblivious of their existence. But from his above-cited statement we may fairly assume that he was not wholly responsible for the design. Adams and his son (the author of the well-known "Essays on the Microscope"), and W. and S. Jones, were the originators of the model adopted by Vincent and his son Charles Chevalier for their early achromatic microscopes, and hence should be entitled to special consideration in any detailed estimate of individual services rendered towards improving the design of microscopes.

Dellebarre's "Microscope Universel."—This microscope is shown in Fig. 61 (copied from Harting's "Das Mikroskop," German trans., 2nd ed., 3 vols., 8vo, Braunschweig, 1866, III., p. 123). The pillar was hinged at *e* for ordinary inclination, and at *f* to enable the body-tube to be placed horizontal, in the latter case the stage, *p p p*, could be inclined with the upper part of the pillar, or slid down below the hinge, when it would remain horizontal, and bottles, &c., could be stood upon it. The body-tube, *a b c*, was carried in a hinged ring, *h*, shutting by a spring-catch, and the screws, *i* and *m*, served to hold the body-tube firmly; the ring, *h*, was attached to an arm, *k*, sliding through a socket, and could be fixed by the screw, *l*, the socket rotated on a long pivot fitting in *n*, and a screw (not shown) fixed it. The stage was hinged to fold against the pillar, the condenser, *u*, was hinged to move laterally also (the hinge for the folding motion is not shown in the figure, but should be like *t*), and the mirror, on gimbal, similarly fitted, also folded against the pillar for convenience of packing. At *c* the long screw-thread is shown on which a large silver reflector was adjustable for illuminating opaque objects, to which I referred in my notes on Lieberkühn's microscopes.

Fig. 61.



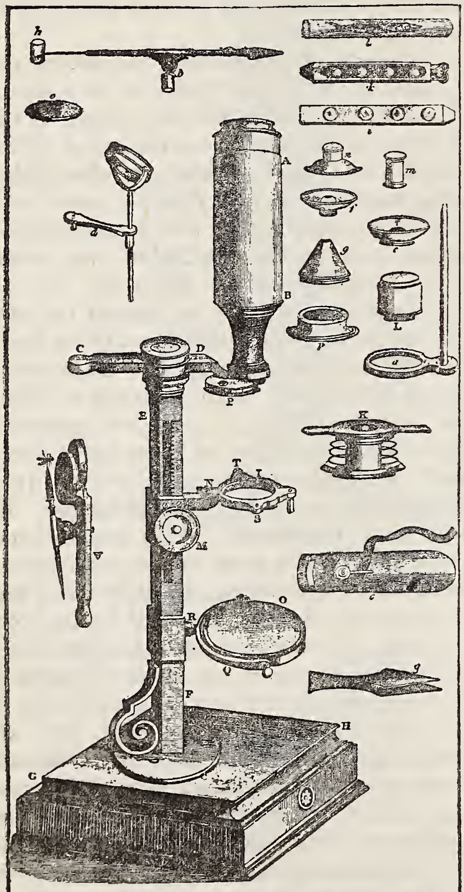
Dellebarre's "Microscope Universel" (1777).

This form of Dellebarre's microscope was applied by a long pivot fitting in the centre of a scroll tripod stand, the feet hinged to fold downwards; in later models the lateral-folding tripod was adopted. Dellebarre also applied a rack-and-pinion to a movable socket connected with the stage, and adjustable by a clamp-screw on the pillar, which was a very inferior arrangement for focussing. In other constructions, however, he applied the rack in front of the pillar, which was a better place.

Dellebarre's microscope was described in detail by Lalande (*vide* Montucla's "Hist. des Mathémat.," III., p. 511), and appears to have been the subject of a special report to the "Académie des Sciences," in June, 1777, by MM. Montigny, Le Roy, and Brisson. He was much commended for his application of six or seven lenses to be used in various combinations as eye-pieces. Lalande states that he deserved special credit for having constructed a microscope composed of six lenses; but his description is too vague to enable us to say whether or not this design followed on the lines of that of Adams (Fig. 56). He dwells upon the fact that Euler had computed a combination of six lenses for a microscope, and also certain achromatic eye-pieces, and appears to imply that Dellebarre carried out the construction; and he refers very distinctly to Dellebarre's "Large Achromatic Microscope" to be seen at La Haye, in 1771, and promises to treat of it later, in "Art. viii.," but on referring to Art. viii. I find nothing by which I can identify the instrument as an achromatic construction. I think Lalande must have been mistaken on the matter, for though I have examined upwards of twenty of Dellebarre's microscopes, some evidently of his early constructions, and some dated from Delft, as late as 1796, and Paris, 1805, I have never seen any eye-piece or objective of his of achromatic form. The value of the combinations of lenses for eye-pieces, so highly commended by Lalande, seems to me very much exaggerated.

The general form of Dellebarre's instruments was much inferior to the best contemporary work produced in England. Fresnel, in his "Rapport sur le Microscope Achromatique de M. Selligue" (1824), remarks (p. 15) that, other things being equal, those microscopes which have the largest field fatigue the eye the least; judged by that criterion, Dellebarre's were inferior to the microscopes of Amici and Selligue, and these were inferior to the English microscope of Adams (which was practically identical with Jones's, Fig. 63). Classifying the microscopes according to the "sharpness of the images," Fresnel found Delebarre's "the worst," Adams's next, and Amici's and Selligue's were "greatly superior" (*ib.*).

FIG. 62.



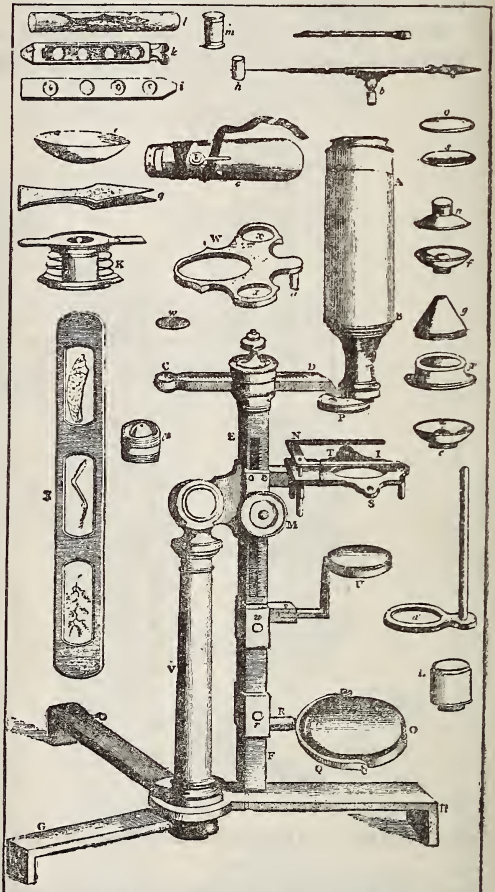
JONES'S IMPROVED COMPOUND MICROSCOPE AND APPARATUS.

(*Ante* 1798).

Jones's "Improved Compound Microscope."—In Adams's "Essays on the Microscope" (2nd ed., 1798), Pl. IV., this microscope (Fig. 62) is given.

We have here Martin's rotating multiple disc, P, of object-lenses; the arm, C D, carrying the body-tube (A, B) slides in a rotating socket on the top of the pillar, to view different portions of an object; a rack-and-pinion acting on the stage is applied for focussing; a carrier, *a*, for the condenser, L, or silver speculum, *e*, with a stem, is to be applied in a sliding socket in the front of the stage above or below; another condenser, D, with gimbal, sliding stem, and arm, can be applied at S or T to illuminate opaque objects; at V the arm, C D, with the disc of lenses, P, is shown in combination with the forceps, B, in use as a simple hand microscope. The other pieces of apparatus need not be described.

FIG. 63.



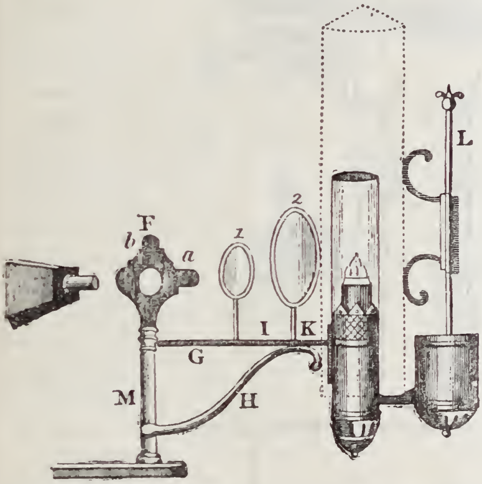
JONE'S'S MOST IMPROVED COMPOUND MICROSCOPE AND APPARATUS.

(1798).

Jones's "Most Improved Compound Microscope and Apparatus."—In the same work (*loc. cit.*) this instrument (Fig. 63, p. 1068) is also figured.

The folding tripod base is adopted. The inclination of the stem on a cradle-joint on the top of the pillar was unquestionably the best system devised up to that date. The arm carrying the body-tube is here provided with a rack-and-pinion, as well as a rotary motion on the top of the stem, E, by which different parts of an object would be viewed better than with Jones's previous arrangement. The stage has clips to hold the objects, and an extra carrier, W, for discs of glass, &c., pivots at S, so that the objects pass successively in the optic axis. The condenser, U, slides on the stem by the socket *u*, the bent arm allowing space for the rack focussing of the stage; the mirror also slides on the stem. A brass cell, *y*, contains a high power, 1-30th or 1-40th of an inch focus, and screws on the nose-piece when the lens-disc is removed.

Fig. 64.



Jones's Radial Swinging Sub-stage (1798).

I regard this form of microscope as the best that was produced in the last century, with the exception of Martin's "Large Universal Microscope" (Fig. 54, p. 1057), of which I believe only two examples are known, and which hardly entered the field of competition.

Jones's Radial Swinging Sub-stage.—In the same work, Pl. IX., this apparatus (Fig. 64) is figured. F is the stage of a lucernal microscope, of which the axis passes through the socket, M, to the base-support; G is a tail-piece swinging laterally by the socket, M, on the axis of the stage, so that the illumination from the lamp, passing through the condensers 1 and 2, strikes on the centre of the stage, and remains on it during the lateral swinging—thus providing radial illumination at all obliquities for transparent or opaque objects. In the earliest form I have seen of this apparatus, bearing the names "W. and S. Jones," no lamp was attached to the tail-piece, but a mirror was made to slide on it.

Adams states that the apparatus was suggested by "the Rev. John Prince, LL.D., now of Salem, Massachuset's States, North America," and that the lamp was attached to it at the suggestion of Mr. John Hill, of Wells, Norfolk.

The modern swinging sub-stage, known as Zentmayer's, which he exhibited at the Philadelphia Exposition, in 1876, acts on the same principle as the above; and the addition of the lamp to the tail-piece of Zentmayer's form by Bulloch, of Chicago, was a revival of Hill's suggestion.

Cuthbert's Reflecting Microscope (Amici's form).—In the early years of this century, Frauenhofer, Amici, and others, experimented with the construction of achromatic objectives, and, despairing of success in consequence of the difficulties of manufacture, they turned their attention to the improvement of reflecting microscopes. Amici is said to have made such improvements in the latter, that even after the announcement (1824) of Chevalier's success with achromatic combinations, he still worked at his reflectors.

In England, Cuthbert, acting with the advice of Goring, brought the construction of reflecting microscopes to the highest point of excellence ever reached, improving even upon Amici's; one of his latest instruments is shown in Fig. 65, p. 1070 (copied from the "Encyclop. Britan.," 8th ed., art. "Microscope," p. 786), which served also as a compound achromatic (dioptric) microscope. Six sets of reflectors were supplied, varying from 2 inches to 3-10ths in solar focus, and of angles of aperture from 13° to 55°. Each set was applied in a separate tube, *b c*, and the three lower powers were supplied with Lieberkühns sprung on the tubes, for illuminating opaque objects; the higher powers were useful for transparent objects only, on account of the shortness of the focus.

Mechanical movements, *m*, are applied to the stage, the construction of which is similar to that known as the "Turrill" system, the two milled heads working on one axis. The fine adjustment is a modification of Cuff's.

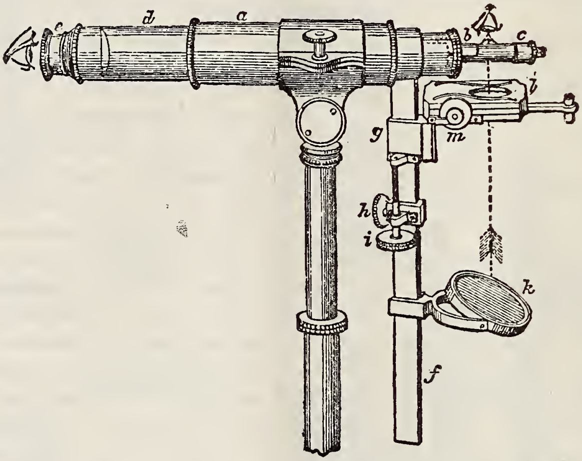
In action as a dioptic microscope, the tube, *b c*, was removed, and an achromatic objective substituted, then by means of an angle-piece the stem, *f*, was carried at right angles to the position shown, so that the stage and mirror were in the optic axis.

I have examined several of these microscopes, and can testify to their general excellence. Cuthbert's work was superior to Amici's, as I found by comparison.

In concluding my notes on non-achromatic and reflecting microscopes, a few remarks may be made by way of *résumé.*

Of simple microscopes we may note that the earliest forms were mere hand-lenses. The next step was probably effected by mounting them at one end of a tube of card-board or wood, the object being held on a needle at the focus, or attached to a plate of glass, or between two plates, and viewed as shown in the "Microscopium Pulicare" (*Vide* Figs. 4, 23, &c.); for magnifying larger objects, the instruments shown in Figs. 7, 9, 10, and 11, were employed with more or less modification. Where higher power was needed, some system of focussing would be adopted, either by sliding the object-carrier or the lens. For still higher power, where the difficulty of making the lenses would limit the power, globules of blown-glass were used; the first production of such globules was by Toricelli (*vide* Poggendorff's "Hist. de la Physique," p. 357). Hooke gave detailed instructions for making these globules, and he appears to have partly ground and polished them. The names of Butterfield (1678) and Della Torre (1765) appear in the "Phil. Trans." in connection with various processes they devised for the production of these globules, and the latter was said to have been specially successful in making very small ones. In some cases the globules were melted on the end of a needle or fine silver wire in a spirit-flame and left adhering, so that they could be handled with facility. Another and apparently better plan was adopted by Sivright (1829), who placed a fragment of glass on a minute hole in a thin plate of metal, and then by means of a blow-pipe and spirit-flame melted the glass so that it ran through the hole, and with careful manipulation it was said that a serviceable lens could be produced having a small diaphragm in its centre, the plate thus forming a substantial mount for the lens. But the uncertainty of the successful production of these globules must have struck every serious worker; and thus we find that Leeuwenhoek used only lenses with ground and polished surfaces, and except in the matter of mounting such lenses in cells so as to be more conveniently applied or changed, no essential improvement was made in their construction until Wollaston, Brewster, Goring, Herschel, Tully, and Coddington worked out by theory and practice the best forms and combinations of simple lenses, resulting in the well-known "Doublets," "Triplets," the "Herschel combinations," the "Bird's-eye" or "Coddington," the "Stanhope," the "Crossed-lens," &c., all produced between 1790 and 1830, *i.e.*, during the years when the possibility of applying achromatism to the microscope presented

Fig. 65.



Cuthbert's Reflecting Microscope (Amici's Form, 1827-8).

itself to the same investigators, with the addition of Beeldsnyder, Van Deyl, Frauenhofer, Amici, Selligue, and the Chevaliers, as a problem to be solved by practical constructions.

With regard to the sequence of construction in the period of nearly two centuries we have dealt with, we cannot affirm that in either the optical or the mechanical design the construction of compound microscopes progressed steadily from generation to generation. Until about 1824, the optical arrangement seems to have drifted about almost aimlessly, with little or no reference to any question of the theoretically best forms or combinations. In Hooke's microscope the field-lens was applied or withdrawn without any apparent conception that a combination might be devised of permanent service, and during the next hundred years the compound eye-piece was hardly improved. The improvement then initiated was in the more accurate mounting of the lenses rather than the adoption of a better optical system.

Then with reference to the object-lenses for compound microscopes, from the date of Hooke's instrument (1665) to the end of the 18th century, plano-convex, or bi-convex lenses were used almost hap-hazard. In the few cases where a combination was attempted, the experiments seem to have been limited to the rude system of placing the plano-convex lenses with their convex surfaces as close together as possible; and even this improvement devised by Divini, and carried somewhat further by Christopher Cock, and by Grindl, led to no permanent advance—the suggestion died out.

If we examine a consecutive series of object-lenses produced during this period, we shall find Campani used a bi-convex lens placed loosely in a wooden cap, with a small central hole, which was screwed on the nose-piece, the lens accommodating itself to the axis without reference to any exact process of centering. In the Hooke instrument the nose-piece was a small cylindrical tube of brass, and the end was made slightly concave (perhaps accidentally); the lens was placed in the concavity, and a brass cap with a plane perforated end was slid over it. In Divini's a similar arrangement was adopted. Later on the lens was held in its cell by a sprung-ring, as in Marshall's, and the higher powers were mounted between two perforated concavities moulded in small cups of thin sheet silver or brass, the cups being held in the cells by sprung-rings; and this latter system was applied to the lower powers also by Culpeper, Cuff, Adams, Martin, Dollond, and others, the perforations in the plates serving as diaphragms, for the opticians soon found that with compound microscopes small diaphragms were essential to render the image tolerable to the eye. In the mean time, in England, and on the Continent especially, many compound microscopes were made with wood, ivory, or horn nose-pieces, in which the lenses were sometimes dropped and held by a sprung-ring, or on which perforated caps of similar materials fitted by screws. Whatever system was adopted, the result was that the lens had not the slightest pretence of being exactly centered. Towards the end of the century Martin, Adams, Dollond, and Jones, in England, and Dellebarre and others on the Continent, began to mount the lenses in accurately fitting cells, in some cases burnishing them in immovably, as was commonly done with achromatic telescope object-glasses. This latter plan was adopted also for the lenses of the eye-piece. There can be no doubt that the severe attention to accuracy of optical workmanship required for the successful production of achromatic telescopes had much influence on the microscope, especially in England, where the best opticians generally constructed both telescopes and microscopes.

As to the mechanical construction, no regular progress was made, and this was probably due (1) to the small number of microscopes manufactured, and (2) to the difficulty of communication, whence the opticians were informed of the improvements devised by their rivals by printed or oral descriptions only, and seldom had the opportunity of actually inspecting the instruments. The large body-tubes, with draw-tubes of the early constructions, imply that low powers were generally used; and conversely, as the body-tubes were diminished in diameter, higher powers were employed, for here the extra-large field would be useless so far as definition was concerned.

The fluctuations in the application or the omission of fine adjustments point to the fact that no pressing need was felt for delicate focussing; the extremely minute diaphragms applied to the object-lenses would account for this partially. And again, the fact that very little original and difficult investigation was attempted with the microscope—the majority of instruments serving for the merest *dilettanti* purposes only—would indicate that the instrument was seldom sufficiently familiarised to betray its weak points; hence the progress in the design was slow and intermittent. It may appear strange, but it is nevertheless true, that on examining the proboscis of a blow-fly with the Campani microscope (Fig. 12), which I believe was made before 1665, I cannot say that the image was inferior in definition, with equal magnification, to that given by microscopes by the whole series of makers preceding the general application of achromatism (1824-1830).

The application of achromatism infused new and vigorous life into the use of the microscope, and gave a great impetus to its development, both optically and mechanically, as we shall see.

ACHROMATIC MICROSCOPES.

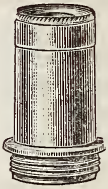
I have already stated that B. Martin published the fact of his having constructed an achromatic microscope objective, and have cited from his "New Elements of Optics" (1759), the passage wherein he described the result of his comparison of the objective with a reflector giving the same magnification. It does not appear that Martin followed up the subject beyond the trials he then described, though in the same volume he promised to treat of the theory and practical construction of achromatic objectives for the microscope, and refers us to a later portion of his treatise, where we find the matter briefly alluded to (Part VI., p. 114) and dismissed.

Euler touched upon the theory of achromatic miroscopes as early as 1762, and in 1771 ("Dioptrica," Petrop., 3 vols., 4to), he dealt with the subject more fully. In 1774, his pupil and friend, Nicolas Fuss, published a small vol. ntitled "Instruction détailée pour porter les unettes . . . au plus haut degré de perfection . . . avec la description d'un microscope . . . le plus parfait dans son espèce" (St. Petersb., 4to), in which plain instructions were given whence any practical optician could construct an achromatic microscope. In 1778, Klügel translated Fuss's work into German ("Anweisung von Fernröhren," Leipzig, 4to), adding further notes and diagrams; and in his "Analytische Dioptrik" (Leipzig, 1778, 4to) the subject was treated of more distinctly from his own point of view.

With reference to fixing with accuracy the dates of the early applications of achromatism to the microscope, and the various modifications in the designs of the instruments issued by the different opticians, I have found so much evidence of inaccuracy among the early writers that, except in the cases where original references are cited, I give *all* other dates under reserve; for in the majority of instances every petty modification has been a subject of more or less controversy as to priority of invention.

Beeldsnyder's Achromatic Objective.—I have not been able to trace any practical outcome from Euler's, Fuss's, or Klügel's theoretical discussions of nearer date than the achromatic objective (Fig. 66) made by François Beeldsnyder in 1791 (*vide* Harting, *loc. cit.*, p. 132), which Harting presented to the Museum of the University of Utrecht. The combination consists of two bi-convex crown-glass lenses, with an interposed bi-concave flint lens; the focus is slightly less than 1 inch. The workmanship is inferior, and the definition leaves "much to be desired." If Martin's achromatic objective of 1759 was not better than Beeldsnyder's of 1791, I am not at all surprised that he was not encouraged to throw aside his older constructions in favour of achromatism.

FIG. 66.



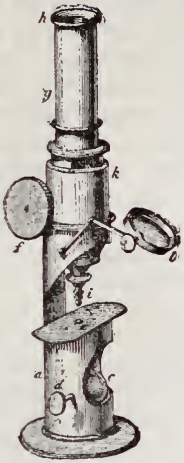
BEELDSNYDER'S ACHROMATIC OBJECTIVE (1791).

Van Deyl's Achromatic Microscope.—Harting (*loc. cit.*, p. 133-4) figures and describes an achromatic microscope which was constructed by Van Deyl in 1807; the mechanism was similar to that of Jones's microscope (Fig. 62, p. 1068), except that Van Deyl applied a tripod base, and the pinion for focussing by the stage passed through the pillar and was actuated by a milled head at the back.

Between 1800 and 1810, M. Charles, of the "Institut," Paris, is said by C. Chevalier ("Des Microscopes," Paris, 1839, royal 8vo, p. 86) to have made small achromatic lenses, which were to be seen at the "Conservatoire des Arts et Métiers;" but Chevalier says they were so imperfect in workmanship that they could hardly have been used as microscopes.

Frauenhofer's Achromatic "Drum" Microscope.—In 1811, Frauenhofer is said (*vide* Harting, *loc. cit.*, p. 136) to have made achromatic doublets; but he does not appear to have been satisfied with them. Whilst his attention was engaged on the construction of microscopes, he modified Martin's later model of his "Pocket Reflecting Microscope" (*vide* my notes under this heading) by adopting eye-pieces of different power, and a condenser on two arms pivoted on the body-tube for illuminating opaque objects (Fig. 67); otherwise the difference in the mechanical constructions was hardly distinguishable. Frauenhofer also attached the microscope on a box, thus rendering it more secure in use.

FIG. 67.



FRAUNHOFER'S ACHROMATIC "DRUM" MICROSCOPE (1811).

In 1815, Amici worked at achromatic microscopes, and abandoned them entirely in favour of reflecting instruments until after the publication of Fresnel's favourable report on the construction of Selligue's achromatic objectives, in 1824.

C. Chevalier, in his "Notes Justificatives" (Paris, 1837, 4to), gave a summary of dates relating to the early history of the achromatic microscope, from which I select those of which he probably had personal knowledge:—

(1.) In 1823-4, Messrs. Vincent and Charles Chevalier made an achromatic microscope with four doublet lenses superposed, according to the plans of Selligue, who exhibited it at the "Académie des Sciences" [on April 5, 1824].

(2.) In 1824-5, Messrs. Chevalier exhibited at the "Société d'encouragement" their improved "Microscope d'Euler."

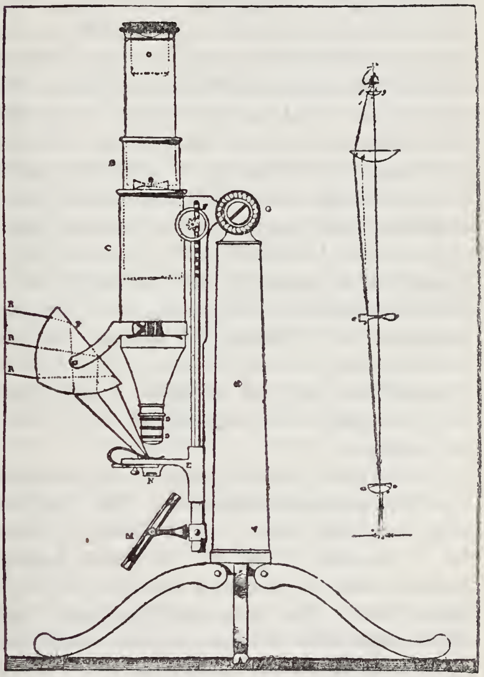
(3.) In 1827, Amici exhibited in Paris his horizontal dioptric microscope, the novelty of which was much admired. Amici applied a series of oculars, cameræ lucidæ for drawing, a movable object-carrier, and "very good" superposed achromatic objectives, but of longer focus than those of Messrs. Chevalier.

(4.) In 1827, a few months after Amici's visit, Messrs. Chevalier exhibited at the Louvre an "Amici" microscope of their construction, which was highly commended by Arago.

Selligue's Achromatic Microscope.—Selligue (1823) was the first to suggest the plan of combining two, three, or four plano-convex achromatic doublets of similar foci one above the other, to increase the power and the aperture, which plan was carried out for him by Messrs. Chevalier.

Fresnel, the eminent mathematician, was appointed to make a special report on Selligue's microscope (Fig. 68) to the "Académie Royale des Sciences" (August 30, 1824). Fresnel states that he compared the objectives with those of one of Adams's best non-achromatic instruments (of which the lenses had been "retouched" and improved by Selligue), and up to a magnification of "two hundred times" Selligue's was decidedly superior; beyond that limit Fresnel did not find the achromatic superior to the non-achromatic—"the contours of the images did not appear more indistinct than in the microscope of M. Selligue" (*vide*

FIG. 68.



SELLIGUE'S ACHROMATIC MICROSCOPE (1823-4).

reprint of Fresnel's "Rapport, &c.," Paris, 1824, 8vo., p. 11). For prolonged observations Fresnel preferred Adams's microscope, because it gave a larger field than Selligue's; this defect in the latter instrument was due to the use of too small a diaphragm "above the objectives" (*ib.*, p. 15). Fresnel specially commended Selligue's plan of placing a small diaphragm between the mirror and the object at N; in one of the Selligue instruments I have examined, the diaphragm consisted of a plate with a graduated series of apertures sliding in a slot, as shown at N.

The mechanism of Selligue's microscope was similar to that shown in Fig. 63 (p. 1068), though Fresnel thought the English model superior (his comparison was with a microscope by Adams, whose model was practically indentical with that of Jones). The focussing was by rack-and-pinion, F, acting on the stage, the pinion remaining stationary and not travelling on the rack; which seems to have been a modification of one of Dellebarre's plans. Two draw-tubes, A and B, were applied within the body-tube, C, the upper one having a bi-concave lens, S (of which two of different powers were provided), at the lower end serving as an amplifier; this was, I believe, the first application of the "Barlow" lens to a microscope. A lenticular prism, P, was attached to a gimbal connected with a ring encircling the body-tube for illuminating opaque objects, which seems to have been a modification of Fraunhofer's plan of pivoting a condenser with two arms on the body-tube of his "Drum" microscope.

Fresnel states that the range of amplification was from 40 to 1,200 diameters. The objectives were composed either of two doublet systems for low-power work, or the four doublet systems were all screwed together for high-power work. The two amplifiers were used either separately or together, and two oculars of different power were supplied.

The diagram shows the path of the rays through the instrument. It should be noted that the convex (crown) was turned towards the object.

C. Chevalier states (" Des Microscopes," p. 87) that Fresnel was unaware at the date of his report that the objectives were constructed by the Chevaliers.

Chevalier's Achromatic Microscope (Euler's system).—Soon after the completion of Selligue's objectives, the Chevaliers found that better results were obtained by turning the plane side of the flint to the object; and in their improved "Microscope selon Euler" they carried out this modification. The mechanism was very similar to that of Jones's microscope (Fig. 63) except that the body-tube was attached to the stem directly, as in Selligue's, and not to an arm as in Jones's.

Tully's Achromatic Microscope.—In 1824, Tully, the well-known optician of London, was induced by Dr. Goring to work at achromatising the microscope, and his first constructions appear to have been at least equal to those of the Chevaliers. The increase of apertures Tully obtained by the achromatic system appears to have betrayed the need of better mechanism in the microscope, accordingly we find him devising sliding rods, similar to those in use with telescopes, to connect the body-tube with the feet, by which greater steadiness was secured; and he also applied mechanical movements to the stage.

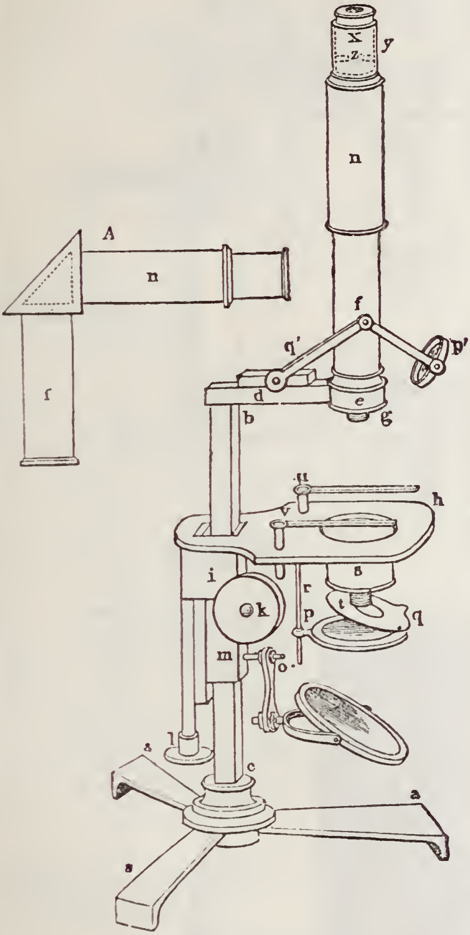
Amici's Microscope.—In 1827, Amici exhibited in Paris his horizontal microscope, in which he is said to have increased the apertures of his objectives by combining doublets with triplets. The point of novelty in Amici's construction was the application of a right-angled prism immediately above the objective, to deflect the rays through the horizontal body-tube. The great convenience of this arrangement—especially for microscopical dissections—was at once appreciated, and the Chevaliers hastened to adopt the model with many modifications.

Merz (1829), successor to Frauenhofer, also applied Amici's system of horizontal body-tube, by placing the right-angled prism in the middle of the body-tube, which modification was adopted by Amici later on.

Fig. 69 (p. 1075) shows one of Amici's constructions, which Harting states was made some years later. In examining a large number of Amici's microscopes, I have found much difficulty in assigning the probable dates. An apparent advance in design in Amici's instruments does not necessarily indicate that the construction was later. This model seems to have been modified from his very early dioptric constructions by the application of a fine adjustment, *l*, at the back acting on the stage, and by the adoption of Merz's plan of using the prism, *a*, in the middle of the body-tube, *f n*, instead of placing it immediately above the objective, as shown in the next Figure.

Chevalier's "Microscope Universel."—This instrument (Fig. 70, p. 1076) was brought out by Charles Chevalier in 1834, shortly after he started a separate establishment from that of his father. He here combined Amici's reflecting microscope with his own dioptric system, together with a number of improvements—especially in workmanship—by which the construction was carried quite beyond the point reached with any microscope of earlier date. The design embodied so many combinations, that the title of Universal Microscope was more justly applied to it than to any of its predecessors, including the Large Universal of B. Martin.

Fig. 69.



Amici's Microscope.

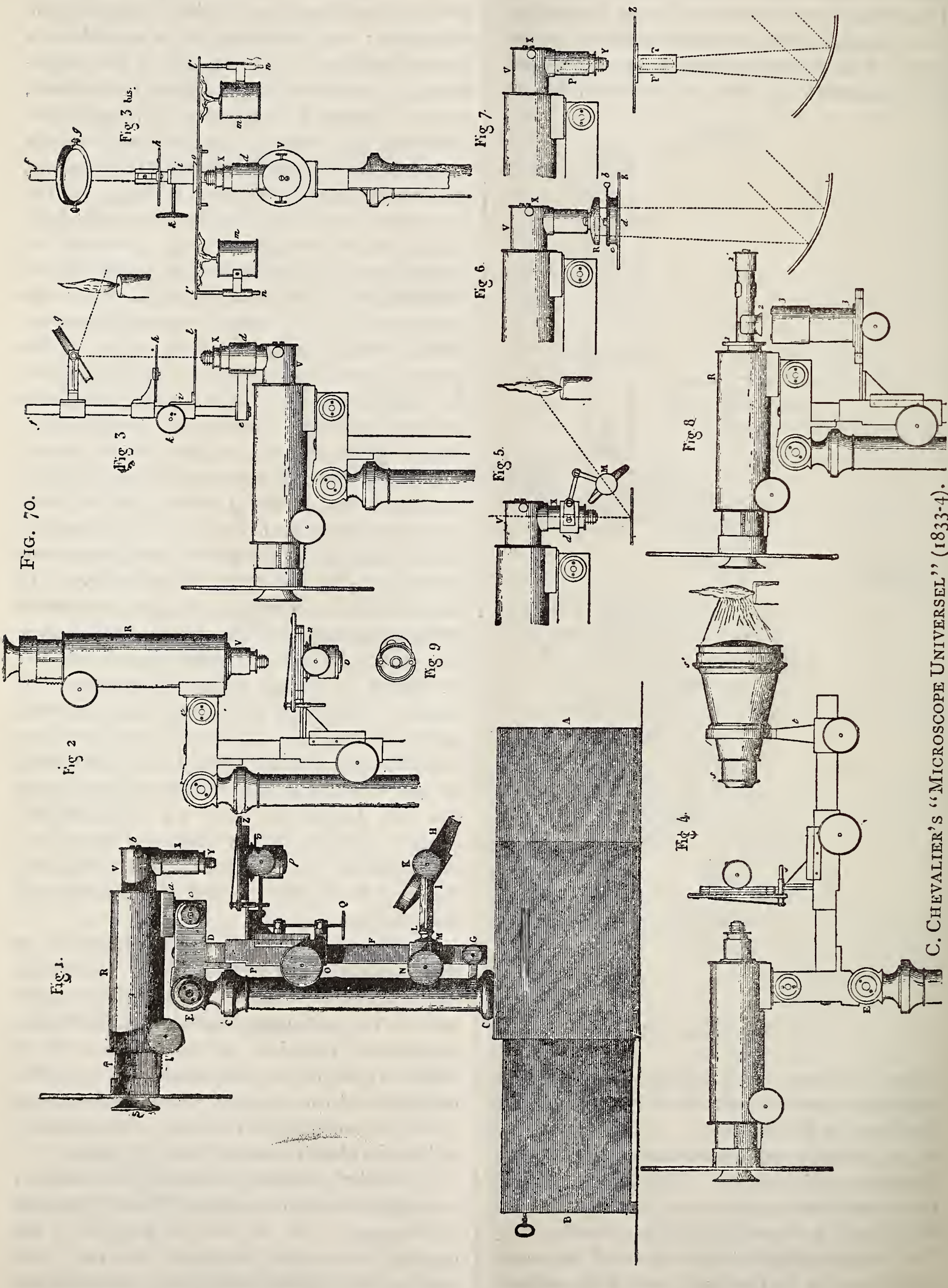
Fig. 1 shows the instrument arranged as a horizontal microscope. The right-angled prism for deflecting the rays into the horizontal body-tube, R, is within the angle-tube, V X. The coarse adjustment is effected by rack-and-pinion, O, to the stage, and a fine adjustment screw, Q, with ball-socket bearings, is also applied to the stage by means of an extra slide in front. The mirror (plane and concave) racks on the stem by the pinion, N. The stage has rectangular motions, actuated by mechanism similar to that known in England as the "Turrill" system. The body-tube pivots laterally at *a*, to facilitate changing the objectives; the draw-tube, T, is moved by a rack-and-pinion at U. In *Fig.* 2 the angle-tube, V X, containing the prism is removed, and an adapter, V, is substituted, in which the objective, Y, is screwed, then the body-tube is raised to the vertical by means of the hinge, *c*, and on removing the pin, G (*Fig.* 1), the instrument can be inclined on the cradle-joint on the top of the pillar. *Fig.* 3 shows the adaptation of the horizontal body-tube for the observation of chemical reactions, &c.; the angle-tube, V X, is turned upwards, and an extra stem carrying the rack stage, *l*, the mirror, *g*, and the rotating disc of diaphragms, *h*, is applied by a socket, *d*. *Fig.* 3 *bis* shows the application of a stage, *l' l'*, carrying a disc of glass, O, to be heated by the lamps, *m m*, also for the observation of chemical reactions, &c. *Fig.* 4 shows the ordinary dioptric arrangement of *Fig.* 2, but inclined to the horizontal, and a powerful compound condenser, *s s'*, applied to rack on the stem. In *Fig.* 5 we find a condensing lens, M, on jointed arms, connected with a socket, *d*, sliding over the tube, X, for illuminating opaque objects. In *Fig.* 6 a silvered glass "Lieberkühn" is shown. In *Fig.* 7 polarising and analysing prisms are shown. *Fig.* 8 shows the combination of the body-tube with Amici's reflecting microscope, the tube, 1 1', carrying the speculum and Lieberkühn (2); 3 3 is an object-carrier applied on the stage to bring the objects close to the tube. *Fig.* 9 is the condenser (*p* of *Figs.* 1 and 2) with disc of diaphragms.

This microscope was directly traceable to the application of achromatism. Chevalier applied numerous pieces of accessory apparatus to the instrument, such as a screw stage-micrometer, eye-piece micrometer, a series of different eye-pieces, compressoria, &c. Independently of the diversity of the movements, the whole mechanism evidences care and precision, entitling Chevalier to high praise.

Chevalier's Simple Dissecting Microscope.—Charles Chevalier modified Ellis's "Aquatic Microscope" as we see in Fig. 71. He applied rack-work focussing to the lens-carrier, and a gimbal and sliding socket to the mirror (plane and concave); his principal improvement was the rotating disc of diaphragms fitted beneath the stage.

This microscope was brought out as a "counterblast" to the "modèle Raspail." In later constructions Chevalier added horizontal screw-mechanism at *b*, passing through the arm-support of the lens-carrier, which was also pivoted at *b*, to facilitate the examination of different parts of the object. The modifications applied to this form of microscope by different makers in Paris were the subject of much controversy. The fact, however, is clear that, after having alluded to the "modèle Raspail" as a mere copy of Cuff's, Chevalier

FIG. 70.

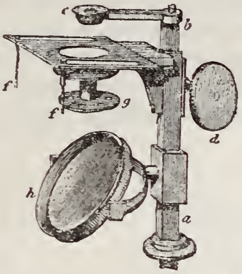


C. CHEVALIER'S "MICROSCOPE UNIVERSEL" (1833-4).

adopted the model, and improved it in many important points.

Andrew Ross improved upon Chevalier's model, by applying a fine adjustment for focussing, which was much needed when doublets and triplets of 1-20 inch focus were employed.

FIG. 71.



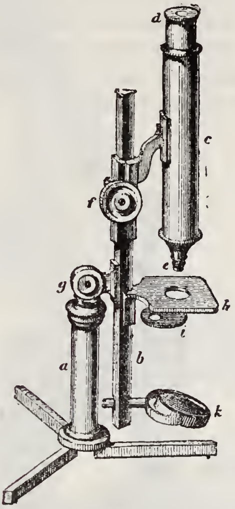
CHEVALIER'S SIMPLE DISSECTING MICROSCOPE.

Between 1820 and 1835 the English opticians, Tully, Pritchard, Dollond, Andrew Ross, and Powell, encouraged by the advice of Wollaston, Brewster, Goring, and others, worked out innumerable combinations of single and compound lenses to be used as simple microscopes. In some cases lenses were made of sapphire, spinel, and diamond, which Brewster and Goring seemed to think would supersede all other forms of single lenses, or even achromatic combinations, for simple microscopes, by reason of the greater working distance their higher refractive indices gave with equal magnification. Pritchard devoted special attention to these "jewel" lenses, carrying the focus as high as 1-100 inch; but the difficulties of manufacture were so great compared with the production of glass lenses, and their general utility was so small compared with that of compound microscopes, that they were abandoned.

Schiek's Microscope.—About 1828 1835, Schiek, of Berlin, and Plœssl, of Vienna, and Pistor, carried out the general form of microscope shown in Fig. 72. The body-tube here travels by means of an arm and rack-and-pinion socket on a stem of triangular section, on which the stage and mirror are also carried. In some cases a fine adjustment was applied to the stage after the design of Cuff's, or again to the travelling-socket—systems more or less complicated, and persevered in, as it would seem, from sheer unwillingness to abandon obsolete forms of mechanism.

The stem, however, may have suggested to Andrew Ross some of his earliest designs of large microscopes, in which he mounted the body-tube, stage, and mirror on a bent stem (bent to provide space for a large stage), carrying the body-tube on the upper part and the mirror on the lower part, so as to be on the same axis, which construction preceded, I believe, the suggestion of a similar design by Jackson.

FIG. 72.



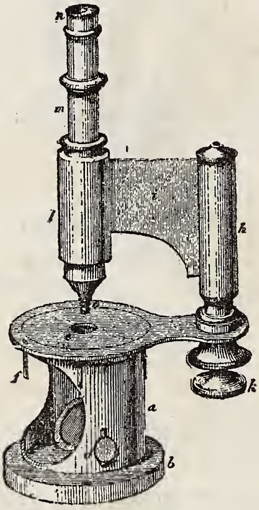
SCHIEK'S MICROSCOPE.

Oberhaeuser's Compound Dissecting Microscope.—About 1830, Oberhaeuser, in conjunction with Trécourt and Bouquet, brought out the instrument shown in Fig. 73 (p. 1078). Oberhaeuser's design was evidently based on that of Frauenhofer's "Drum" microscope (Fig. 67), but the modifications and improvements were so great as to overwhelm Frauenhofer's slight modifications of Martin's original constructions of the last century; so that Chevalier's attempt to fix upon Oberhaeuser the charge of being a mere plagiarist is absurd—hardly needing consideration.

The application of the socket-support, *l*, for the body-tube, and bracket, *i*, connecting it with a second socket, *h*, mounted as a sheath on a pillar through which a fine adjustment screw, *k*, acted for focussing, was in itself an improvement of first-rate importance; Oberhaeuser, however, combined this improvement with another equally important one, by mounting the pillar on a plate made to rotate on the optic axis on a drum-base, and serving as the object-stage—a combination of improvements in the mechanical design of the compound microscope entitling Oberhaeuser to a conspicuous place among the inventors who have sought to perfect the instrument.

For the purpose intended, *i.e.*, as a compound dissecting microscope, no instrument of previous date was made at all comparable with this of Oberhaeuser's for convenience. The stage was so well supported that the dissecting operations could be observed without the slightest trace of flexure or tremor, even with the hands resting on the edge; whilst the convenience of rotating the object so as to view each part most favourably, and without lateral movement in the field, must have presented itself as a new and most important advance to the microscopists of that date. The success of the model was, I believe, quite unprecedented in the history of the microscope. The design was copied by the Ingénieur Chevallier, Lérebours, Soleil, and Nachet, senior, with modifications principally with reference to the mechanism of the sub-stage; in some cases the sub-stage was mounted in a gimbal actuated by a lever, in others a rack-and-pinion movement was applied, and here and there more convenient means were applied for changing the cylinder-diaphragms or the condenser. Prisms were occasionally applied to the body-tube either to form a horizontal arm or to be more or less inclined. Rack-and-pinion movement was applied to the body-tube by Oberhaeuser in addition to the sliding socket; and a similar movement to the draw-tube (first devised, I believe, by Dr. Cuno Fischer, of St. Petersburg) made a "pancratic" arrangement.

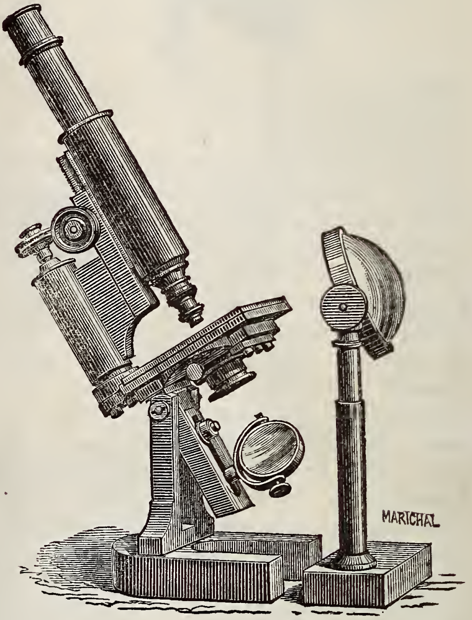
FIG. 73.



OBERHAEUSER'S COMPOUND DISSECTING MICROSCOPE (1830 ?).

Hartnack's Microscope (Oberhaeuser's form).—The substitution of the horse-shoe base and pillar (Fig. 74) for the drum-base of Oberhaeuser's model was, I believe, carried out by Hartnack, Oberhaeuser's nephew, and was evidently devised to facilitate the use of oblique light. With the drum-base the mirror remained in the axis, and thus could not be used to provide oblique light beyond a few degrees from the axis, depending on its size and focus; but the horse-shoe base allowed the mirror to be swung on a pivoted arm sliding in the pillar, which was, of course, an improvement. The cylinder-diaphragms or a condenser were contrived to fit in a sliding sub-stage, with a cylindrical socket which can be centered to the optic axis by the optician, but which the amateur adjusts with much difficulty. In the early models of this design the focussing-screw remained, as before, at the lower end of the pillar, and then the microscope could not be inclined; Hartnack moved the actuating milled head to the top of the pillar, so as to permit the application of a horizontal axis to the upper ends of the pillars

FIG. 74.

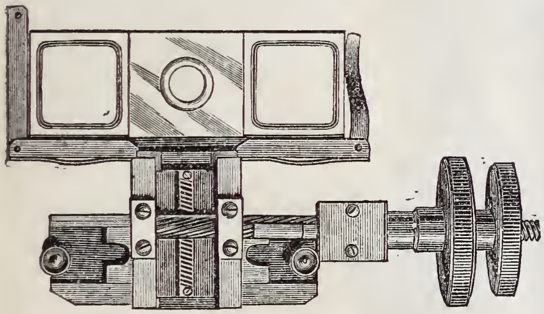


HARTNACK'S MICROSCOPE (OBERHAEUSER'S FORM).

on which the body-tube, stage, and tail-piece could be inclined.

This form of microscrope has been generally adopted on the Continent, and is known as the "Continental model." As a working instrument, the general design is, in my opinion, the most serviceable extant. That the mechanical arrangement is susceptible of improvement, I have no doubt; for example (1), the base is not safe when the stage and body-tube are inclined (which difficulty has been met by Nachet and Zeiss, and others, by extending the base behind the pillar supports); (2) the sub-stage should be applied to the tail-piece with rack-work and centering arrangements, on the plan adopted in the better class of English microscopes; (3) the fine adjustment screw is far too rapid in action for high powers; (4) a convenient mechanical stage is needed, that can be readily applied or removed (my next Figure shows a design I have suggested for this purpose).

FIG. 75.



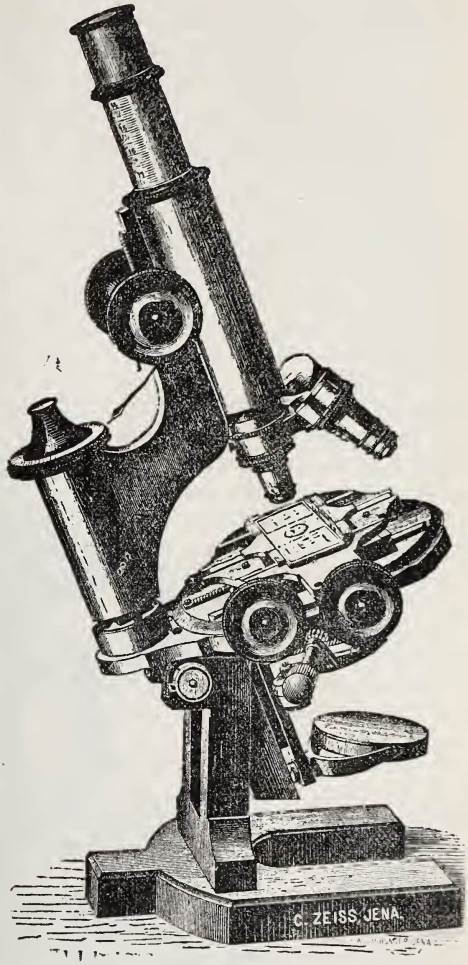
MAYALL'S MECHANICAL STAGE.

Mayall's Mechanical Stage.—The aim of this device is to provide mechanical movements for the object-slide, without the use of travelling plates. The slide is placed on the surface of the stage (in the Oberhaeuser form, or on the rotating stage-plate of the usual English model), being held in a hinged frame connected with the mechanical movements.

The apparatus is shown in Fig. 75, as made by Swift and Son; it is attached to the surface of the stage by the milled-head screws shown at either end of the lower part. The curved arm on the right, and the straight arm on the left, are hinged with sprung fittings like the blades of a pocket-knife. As the slide lies in contact with the surface of the stage (or of the rotating stage-plate), the flexure that is found more or less in every form of mechanical stage, acting by one or more superposed plates, is obviated.

In practice I have found it advisable to gum a narrow strip of paper near the ends of the under surface of the glass slides, to remedy the inconvenience due to any unevenness of surface.

FIG. 76.


C. ZEISS JENA.

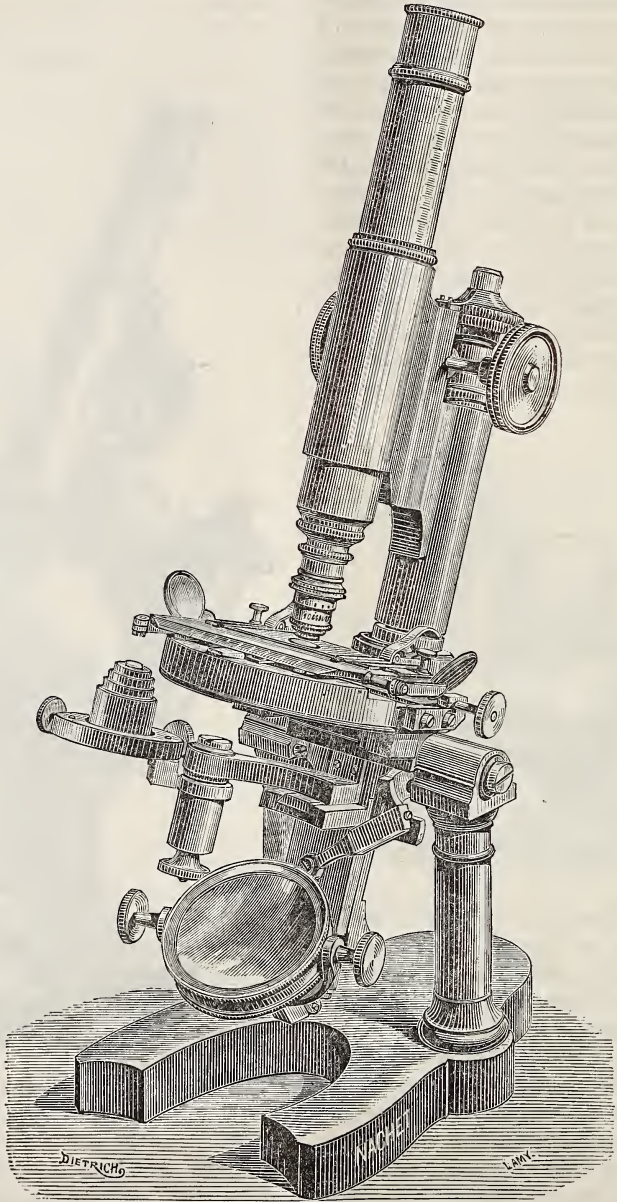
ZEISS'S MICROSCOPE.

Zeiss's Microscope.—In several points of detail the mechanism of Zeiss's microscope (Fig. 76) is superior to Hartnack's, while the application of Abbé's condenser has added to its general efficiency, especially for oblique illumination. In Zeiss's latest models mechanical movements are applied to the stage, as here shown.

Nachet's Microscope.—In this latest model

(Fig. 77) M. Nachet claims to have much improved on the older forms of fine adjustment used with the "Continental model," by reversing the action of the spiral-spring. It is now arranged to draw the sheath connected with the body-tube *downwards*, instead of pushing it upwards as formerly; by this alteration the fine adjustment screw controls the movement by the contact of its point with a hardened steel-plate, greatly reducing the friction, whereas formerly the screw passed through the nut on the top against which the spiral spring pressed upwards, causing much friction.

Fig. 77.



Nachet's Microscope.

The *sub-stage* is centering, and, to change the condensers, &c., can be turned away from the axis of the body-tube on a pivot, which can also be removed when required, being attached to a short arm sliding in grooves in the tail-piece, and controlled by a lever. The pivot contains a slow motion (by screw), allowing the sub-stage condenser to be focussed exactly on the object.

The *mirror* is attached by a series of short arms with three articulations acting at right angles to each other, so that it can be moved in all directions for oblique illumination.

Mechanical movements are applied to the stage, and M. Nachet has devised a special arrangement of small mirrors, by which the approach of the objective to the cover-glass can be readily seen—a matter of importance to those who use high powers only occasionally.

Figs. 53, 54, 56-65 are reproduced from the works cited; Fig. 55, from Quekett's "Treatise on the Microscope" (above-cited), p. 27; Figs. 66 and 75 were photographed on the wood-blocks from the instruments; Figs. 67, 71-73 reproduced from Hannover's Treatise "On the construction and use of the Microscope," English trans. by John Goodsir, F.R.S.E., Edinb., 1853, 8vo.; Fig. 68, from the Plate in the above-cited reprint of Fresnel's "Rapport, &c.;" Fig. 69, from Harting's "Das Microskop" (above-cited), iii., p. 169.

ELEMENTARY LECTURES.

ELECTRICITY.

By Professor George Forbes.

Lecture V.—Delivered May 15, 1886.

In my last lecture I commenced by showing you the remarkable experiment which was made by Professor Oersted, of Copenhagen, and I proceeded to tell you that nearly all the phenomena of electro-magnetism, which have been the foundation of the great progress in electrical science and its applications since that date, could have been deduced from that experiment of Oersted. Oersted's experiment has been spoken of by some as having been an accident. At the moment that he saw the influence which a wire carrying a current had on a magnet he was trying to detect the influence in a totally different manner, he was trying to detect the influence of the heat generated upon the magnet, but instead of that he found the remarkable result which formed the basis of our demonstrations in the last lecture. It has been said by some that Oersted's experiment was the result of an accident, but I protest against any such interpretation being put upon it. It shows a comparatively feeble knowledge of the means of progress in scientific discovery. It is by such constant labour, and the readiness to grasp the importance of unexpected phenomena that present themselves, that the greatest discoveries have been made. Were we to say that the philosopher studying in his laboratory at numerous experiments, when he first happens to come across something he had never found before, and tests it, and finds it to be a new fact—were we to call that an accident, then forsooth we should have to say that the discovery of the planet Uranus was an accident, that the discovery of the many continents and islands of the world, and half the discoveries of philosophers in their laboratories, have been accidents. As the result of that brilliant discovery of Professor Oersted, we saw last week that several conclusions could be drawn. The continuous rotation of a magnetic pole round an electric current, the motion of a wire carrying the electric current in the neighbourhood of a magnet, and the attraction or repulsion of two parallel currents according as they were in the same or in opposite directions, these discoveries of Faraday and Ampère are the necessary conclusions from Oersted's experiment. At the same time that does not detract in the least from the originality or the merit of these great men who followed out the experimental work, and proved the truth of these facts which were new to science. And so it is in the present day; frequently we find new discoveries which, upon investigation, are found really to be deducible from what we knew before, but that in no way detracts from the merits of those investigators who by their laborious researches have introduced facts which were new at the time to science, and especially is this the case in electrical science. Frequently we have new facts presented to us—facts which none of us before have been acquainted with, and it is common to say, "Oh, such facts are perfectly deducible from the theory of electricity." That may be so, but it does not in the least detract from the value of these new researches.

I will, with your permission, before going on to the question of induced currents, which is a mere continuation of the deductions which were made from Oersted's experiment, illustrate the subject of the last lecture by means of a different apparatus—a piece of apparatus of great beauty, and one which with the same fidelity proves the rotation of a current of electricity round a magnet. I have here a globe partially exhausted of air, the density of the air within it is very much smaller than the density of the atmosphere around us. I shall pass a current of electricity through this globe, passing it along the outside of the tube which goes down from the top through the middle of the globe. Within that tube I have a piece of iron with a coil of wire round it, so that with the wires connected to a battery I am able to magnetise that central piece of iron either with the north pole downwards, or with the south pole downwards. We saw last time, by numerous experiments, that when a current is travelling parallel to a magnet it tends to rotate round it in one direction or another, according to the direction of the magnetisation. In those experiments we always used a solid body, generally a copper wire, to convey the current of electricity. In this case I am going to pass the current of electricity through attenuated air. When we send a current by means of that grand induction coil through there, you see the signs of a stream of electricity, a current is passing parallel to the magnet from the top to the bottom. I am now able, by means of a commutator, to magnetise that bar of iron. I will magnetise it first with the north pole downwards, and you see a continuous rotation of the current of electricity round the pole of the magnet. I will now reverse the direction of magnetisation, and put the south pole downwards in place of the north pole; the current stops, and immediately rotates in the opposite direction.

All the phenomena of the movement of wires carrying currents which were shown in the last lecture, were shown to be due to the presence of a magnetic field. The wire itself acts in such a way as to create a magnetic field in its neighbourhood. The magnet itself, however, may be looked upon as an agglomeration of electric currents, and I showed you a model representing the ideal magnetic molecule. Let us consider now the question of Oersted's first experiment, or one of the experiments that follow from it. I will take the case of a coil of wire with a magnetic pole in its neighbourhood. When I pass a current of electricity through that coil it moves that magnet—moves it against the force of terrestial magnetisation which is trying to hold it in its place. Therefore, when the current is passing through a coil of wire, it uses up energy in moving that magnet. Now the principle of conservation of energy proves to us that the motion, like that of a magnet towards the coil, or away from the coil, cannot take place without the consumption of energy. I have a current of electricity passing through in the coil, and as soon as I bring it near the magnetic pole, energy is consumed. What is the energy which is consumed? Where does it disappear from? Clearly it must disappear from the energy of the current which is circulating in the coil. In other words, when the magnet pole approaches towards the coil the energy of the current is diminished. The diminution of this current by the approach of the magnet towards the coil simply means that there is a tendency to set up an inverse current by the approach of the magnet; in other words, by a plain consideration of the principle of conservation of energy, we are able to deduce from Oersted's experiments this remarkable fact, that when the pole of a magnet approaches a coil, a current is generated in the coil by the influence of their mutual approach.

However desirable it may be to trace the connection between all these different phenomena, the facts themselves must be demonstrated, and we must see the experiments before us in order to convince ourselves of their reality. I have on the mantelpiece a small galvanometer which consists simply of a small magnet attached to a highly polished mirror, and placed in the centre of a coil of wire which surrounds the magnet. The lime-light is thrown upon the mirror, which reflects the beam of light to the scale on the wall. A vertical wire is placed in the position which would be occupied by the slide of a magic lantern, so that we shall have an image of a wire moving upon the screen in accordance with the motion of the magnet within the coil of wire. The ends of the coil of wire are carried away, and are continuously connected together, so that that coil of wire has practically no ends, for the two ends coming over here are coiled up into a little bundle of half-a-dozen turns. I hold in my hand a magnet with the north pole pointing towards you. My object in this experiment will be to prove the truth of the deduction which we made just now, and to show you that simply by the approach of a magnet into a little coil of wire like that, we are able to introduce a current of electricity into the wire which will circulate round the coils of the galvanometer, and so deflect the compass needle which is there suspended, which will be evidenced by the motion of the spot of light and wire on the screen. At the present moment it is my intention to force the north pole of the magnet within the coil of wire; on doing so, the spot of light moves to the right. If our theory be true, it would immediately follow that on the withdrawal of the north pole from the coil we should get a motion in the opposite direction. I withdraw the magnet, and the spot of light moves to the left. I will now introduce the south pole instead of the north pole. It moves to the left, in the opposite direction to what it did before. I will now complete the experiment by withdrawing the south pole, and the motion of the spot of light in this case is to the right.

A vast number of experiments were undertaken by Faraday, who made this brilliant discovery, extending the application of these general principles; and just as we have found that the experiment with the magnet and coil is a direct result of the brilliant experiment of Professor Oersted, so we shall see that other experiments which were performed by Faraday are a necessary and natural consequence of the results arrived at by the French philosopher, Ampère. Ampère found that when two coils of wire were placed in proximity to each other, and currents of electricity were following through both, there was attraction or repulsion between them according as the direction of the currents of electricity were the same or opposite to each other in the two coils. Exactly similar reasoning to that which I used a short time ago, depending on the principle of the conservation of energy, proves to us that this energy which is thus transformed must be derived from the energy in the currents, and that at the moment of the approach of the two coils there must be a diminution in the strength of the currents of electricity. But if there be a current of electricity in only one of the coils, then the approach of the two coils together must cause the creation of an inverse current in the second coil. I have connected now the one coil to the galvanometer, while the other coil is connected with the commutator, by means of which I am able to send a current of electricity through it. At present there is no current passing through it. I have now a current of electricity passing through my coil, and I will approach the coil towards the one which is connected with the galvanometer. The motion will, in this case, be very much larger, because I am using much larger coils. It moves nearly to the end of the scale. That shows the creation of a current in the induced coil inverse to the direction of the current in the inducing coil when the spot of light went to the right. When I withdraw the two coils we see, in the same way, the motion of the spot of light to the left. I will now reverse the direction of the current of electricity, and we shall find the opposite effect will take place. I shall now be able to prove conclusively that a current induced in the second coil is always in the opposite direction to that of the inducing coil. When I approach the coils now the motion of the spot of light ought to be to the left, if the induced current is in the opposite direction to the inducing current. On approaching them, you see the motion is to the end of the scale on the left. In conclusion, I will show you that when I keep the coils close together, and make or break the circuit, the same effects take place. I first make the circuit, and the spot of light moves to the right. That is equivalent to approaching the two coils together. I will now break the circuit, and the spot moves to the left, which is equivalent to the opposite effect of withdrawing the two currents from each other.

There is one more experiment I will show you in connection with this, and that is the enormous influence of the introduction of a bar of iron into these coils. We have seen that the whole of these electric magnetic effects are due to the production of magnetic fields in the neighbourhood of wires. If then I introduce a bar of iron partly into the secondary coil, and partly into the primary coil, and then make or break the circuit, the deflection of the spot of light will be very much increased, in fact, it is moved right off the scale, and swings half round the room.

Faraday long continued these experiments, and tested the accuracy of his conclusions in a great variety of ways. It is all very well for us just to look at a few conclusive experiments like this, and to say they are the necessary conclusion from Oersted's experiments, but that is not sufficient to convince the philosopher when he is investigating these new facts, and it was a laborious study of years on the part of Faraday that completely established the truth of the whole of the laws of induction. Faraday showed that terrestrial magnetism was sufficient to induce a current of electricity in a moving wire, and it is evident that this must be the case, and we shall see that it is so by means of this apparatus. I will place this coil of wire so that I can rotate it about a horizontal axis which will cut the magnetic field created by the earth's magnetism. The lines of force in the earth's magnetism are going in a direction perpendicular to the axis about which I rotate the coil. You see, then, that at any moment while this half of the coil is cutting the lines of force in one direction, the other half is cutting the lines in the other direction. It follows from this that a current of electricity will be created in the one half of the coil from your left to your right, and in the lower half of the coil it would be at the same time from your right to your left. The combined effect of this is to produce in both parts of the coil continuous current in one direction round the coil. But after this has accomplished half a revolution, a simple examination of it will show you that the tendency would be to create currents in the opposite direction in the wires. It would be in the same direction in space, but, therefore, in the opposite direction in the wires at each half of the revolution. In order to get over that difficulty, what is called a commutator is introduced, by means of which the direction of the currents which are taken here to the galvanometer are reversed at each half revolution. Thus, if there is a reversal in the coils of wire at each half revolution, and also reversal in the galvanometer, the direction will be caused to be continuous, and then by turning the handle rapidly we are able to add together the effects of the successive half rotations; we shall have a continuous deflection of the spot of light on the scale due to the action of this current created in the moving coil, and carried from the commutator to the galvanometer which we have been looking at before. I will rotate this coil, and you see the movement of the spot of light to the right. I will now rotate it again in the opposite direction, and it moves to the left. I will intensify your belief in this by causing the spot of light, after a moment, to come to rest by alternately reversing the direction of the current. The generating of currents of electricity by this means, that is to say, by the motion of a wire in a magnetic field, have given rise to practical applications of the very highest importance, and without speaking of those powerful currents of electricity which are created by our dynamo machines, I will introduce at least one illustration here of the intensity of these currents which can be so induced. I have upon the table an apparatus consisting of a horse-shoe magnet with a soft iron pole piece, and round this pole piece are bobbins of wire, and there is a keeper placed on the poles thus created at the end of the piece of soft iron. At the present moment there is an intense degree of magnetisation in these iron cores round which the coils of wire are placed. If I suddenly remove the keeper from the magnet, I diminish the amount of magnetisation of the soft iron pole piece to a very great extent. This change in the intensity of the magnetism inside the coil is equivalent to the passing of lines of force through these coils. The result of this diminution in magnetism is to create an intense electromotive force in the wires, which electromotive force may be utilised for several purposes. At the present moment I have placed upon it one of those fuses generally known as Abel fuses, from the name of your Chairman, who constructed them for exploding charges in mines, and the current which we shall be able to get simply on detaching suddenly the armature from the magnet will be sufficient to explode the little fuses which are connected with the wires which surround the soft iron poles. You saw the explosion when the armature was removed, that, I need not say, was a current of very great intensity indeed, but of very short duration, but it is very powerful during the short time that it lasts, and is capable of overcoming very great resistance.

There are many other experiments illustrative of induction which I should wish to show you. Here is one of a very important character, and very instructive when we see the reason why it works. I have a copper disc supported on a vertical axis to which I have the power to give very rapid rotation. I have above that a sheet of glass considerably larger than the copper disc, and I attach it, and fix it in position. Upon the centre of the sheet is a pivot with a compass-needle attached to it. When I rotate the copper disc the compass-needle is seen to rotate in the same direction. There are no air currents capable of influencing it, because the glass plate shields the compass-needle from the influence of currents of air. This was discovered by Arago, and Faraday was the first to show that it was simply a consequence of those induced currents which he had been investigating. Now, let us see how the explanation is arrived at before we actually try the experiment. Consider this north pole and the copper disc is moving past it, therefore, a current of electricity is generated in the copper disc. But when a current of electricity is in the neighbourhood of a pole it causes that pole to move. Therefore the rotation of the copper disc has the double effect of first inducing a current by its own influence on the pole, and then re-acting under the existence of the current upon the magnetic pole itself, and so being able eventually, I dare say, to turn it right round, because it circulates in the same way. I will now rotate the copper disc. You see the motion of the needle which is under the directive influence of the earth's magnetism, but still it goes on, and is able to overcome the earth's magnetism, and it is rotated in the same direction as the copper disc, and gradually acquires velocity, and if I continued the motion, eventually it would rotate at almost exactly the same speed at which the copper disc itself is rotating.

This phenomenon, after it had been explained by Faraday, was also examined by others, and there are a vast number of instructive results which come from modifications of this experiment. I am only going to show you one modification which was first shown to me by Professor Guthrie, and it seemed to me a very striking experiment indeed. I suspend from a gallows there a horse-shoe magnet so that the poles are just above the rotating copper disc. The effect I wish to show you is this, that there is repulsion from the rotating copper disc to the poles of the magnet. Why should there be a repulsion? It is due to what has been spoken of as electro-kinetic momentum; that is to say, an electric current has a species of momentum much like a moving body has a kind of momentum, although we are very certain that electricity is not a material substance, yet it is influenced by the electromotive force very much as material substances are influenced by ordinary force, and there is such a thing as momentum, that is to say, a current once created tends to maintain itself. One of the consequences of this is, that when we rotate the disc, the action, whether attractive or repulsive, lasts for a little time, it does not take place at the same points where we should expect it to take place if we did not consider electro-kinetic momentum. If we do not consider this momentum, then as any point of the copper disc is approaching towards the magnet it would be repelling it, tending partly to turn it round and partly to raise it; but any point of the copper disc in receding from the pole of the magnet would be tending to attract it, which would partly pull it down and partly turn it round. If there were no electro-kinetic momentum, the upward motion tended to be produced by the approaching part of the plate would be equal to the downward pull produced by the receding part of the plate; but if there be electro-kinetic momentum, so that the current once established tends to keep itself going, then the action of the approaching part would be nearer to the pole than the action of the receding part, and therefore the repulsion upwards produced by that part would be in excess of the attraction downwards produced by the receding part of the copper disc. I think this is now pretty well balanced. You see there is repulsion; the magnet is pulled away from the copper disc, and retains that position, and never swings back again; but the magnet is distinctly at the distance of about an inch and a half from the plate, whereas it was almost in actual contact before. It would lead me very far if I were to go on to all those phenomena of which that is only the germ, due to electro-kinetic momentum. I shall have a few words to say about it in a minute or so, but in the first place I want to show you an experiment exhibiting the powerful nature of the induced current when a good conducting material is moving in the neighbourhood of a magnet. I have here a copper medal placed between the two poles of a powerful magnet. I shall give this medal a considerable spin. I will twist the thread which suspends it between the poles, and when it is twisting so that it will maintain a spin for a long time, I shall replace the poles so that it may spin freely between these two magnetic poles. As soon as I connect the magnetic current by connecting this electro-magnet with a powerful battery, this excellent conductor, this copper medal will be creating in itself currents of great intensity as it cuts the line of magnetic force, and the result of that will be that these currents will react on the magnet, and the magnet will always tend to stop motion which gave rise to the current which is possessed by the body, and, therefore, when it has acquired velocity, and when I connect the magnet with a powerful battery, you will see the rotation of the copper medal retarded or stopped. It is now rotating rapidly; I make the contact and the rotation is immediately stopped. If I take away the magnetism, the copper again spins with great velocity. When we use so large a mass of metal as this, the intensity of the current created in it depends partly on its form, and partly on its conducting power. The greater the conducting power of the material the greater is the effect of this kind which is produced. If I used a comparatively bad conducting material, such as lead, the effect would not have been nearly so marked; but by using a high conducting material, such as copper, the effect is very appreciable indeed. Thus the intensity of induced currents of bodies of the same form subjected to the same inducing influence, depends on their conducting power. This property has been utilised by Professor Hughes in a very ingenious instrument which he called the induction balance, in order to detect minute differences in metals. Not only was he able to measure the difference of conductivity of different metals, but of the same metal with slight variations of impurities in it. I can only show you this apparatus, because in speaking of induction it is essential that attention should be drawn to this very beautiful apparatus. It consists essentially of two pairs of coils, one pair at each side of a bar. One rests above the other with a hollow cup in the centre. When we have the piece of metal in the centre of one of these coils, when we send a current through one of the coils, a current is induced in the second coil by the action of the one through which the battery is sending the current; but there is something more than that; in the centre of the coil we have placed a mass of metal, it may be of good conductivity, certainly of comparatively low resistance. Currents are induced in that mass of metal, they re-act on the second coil under, and the intensity of this re-action can be shown by connecting the second coil with a telephone. This was the means by which Professor Hughes examined it. Then when he made and broke contact with the primary coil he got sounds on the telephone which depended for their intensity on the kind of metal which was inside, and by arranging two pairs of coils in this way, and getting them in such a way that when there was no metal in the centre of either pair of coils the one counteracted the other, and no sound was heard in the telephone, and then when a piece of metal was introduced to one or the other, the effects were apparent by the noise in the telephone, and so delicate was this test that he found, on actually placing on the centre of two coils two sovereigns turned out from the Mint by the same machinery, he was able to trace a difference in the effect, either due to resistance, or to the difference in form, or to the difference in material of those two sovereigns, though the two sovereigns were freshly turned out from the Mint at the same time, both perfectly new, and had never been touched. By being able to test resistances of masses of metal, instead of the resistance simply of wires of metal, as we have usually done, Professor Hughes has been able to arrive at some very remarkable conclusions. One illustration is on this scale I have here. On it I have three pieces of copper representing the scale of conductivity of these three different specimens. The specimen which I have on my right, which is so low down on the scale, is common commercial copper—its conductivity is indicated by the short distance; up here in the form of wire we have a high conductivity copper which is used for all refined laboratory research, which is nearly pure; the conductivity is represented by about three times the distance, while beyond either Professor Hughes found that a deposit of copper by electrolysis gave conductivity far in excess of the finest copper obtained for use by experimental processes.

I am afraid time will not permit me to explain this more recent experimental and beautiful apparatus of Professor Hughes, but perhaps it would be best if I were to leave that for the present, and speak of it in the next lecture, but I might be able to allude to this induction bridge, as he has called it, as conveying the object for which it was designed. We all know now that when a current of electricity is passing through one wire, and there is another wire in its neighbourhood, that the act of passing the current in the one induces a current in the opposite direction in the other. If the current came through these wires simultaneously, each one would at the same moment be tending to create a current in the opposite direction to the other wire. Thus the current would diminish owing to its mutual influence between the two wires. But this effect does not in the least arise from the fact of there being two separate conductors, but owing to the fact of there being two conductors. If those were a solid mass of conducting material like a thickish wire, each part of the wire which is carrying the current itself when at the moment of making or breaking current would influence the other part. The current is not so strong at first as it would be if there was none of this self-induction, as it has been called. I will go no further with that question at present, I simply say this apparatus was devised for studying the principle of self-induction which is possessed by wires, which is really the mutual induction of the different parts of a wire upon itself, and by means of this apparatus Professor Hughes was able to enlarge our knowledge very considerably. I will just send a current through it. I have here a bridge of iron wire; the interrupted current is caused by clockwork. This is a bridge like the Wheatstone bridge which I showed you the practical working of in my second lecture. The existence of the current is shown by the noise of the telephone in the box. We are able to silence that noise by a suitable choice of the resistance. The little noise you hear now is the noise of the clockwork; the noise of the telephone has entirely ceased, because the Hughes induction bridge has been balanced. Now there are two ways of arranging this, so that either the current of the battery may be made or broken, or else I might arrange the clockwork so that the current going to the telephone from the points where it is attached is made and broken. At present, the wires of the telephone are joined, though there is silence as far as the telephone is concerned. I will now change it to the condition in which the current from the battery is made and broken in succession, and then when it is steady, by listening attentively, you can hear the noise in the telephone; you cannot hear it when it is in an unsteady condition. This is all the distance I am able to go in illustrating this experiment of Professor Hughes.

I will now show you a few experiments with the magnificent induction coil I have with me upon the table, lent me by Mr. Apps, who constructed that splendid induction coil which was in the possession of the late Mr. Spottiswoode. An induction coil simply consists of primary coils of wire wound round a bundle of iron wires, that is connected with a battery in such a way that we are able to make and break contact in succession. Thus in the primary we have electric current conveying the current itself, but with rapid interruptions. Round that is a high resistance coil of wire, and the making and breaking of the current in the primary tends (chiefly on account of the influence of the iron which is in its centre) to cause of itself currents to be created in the outer coil which creates enormous difference of potential incomparably greater than that of any ordinary battery, or even of the Wimshurst machine which we examined in the first two of these lectures. I will first show you the continuous discharge between those two points—almost continuous—when I make and break the primary circuit. You see what an enormous length of spark we are enabled to get. This enormous length of spark is obtained simply from four cells of a battery which in themselves could not produce a spark 100th or 1000th of the length you see there. I will now put on a Leyden jar in the secondary circuit, the manner in which for spectroscopic work such an induction coil is generally employed. By this means we do not get anything like so long a spark, but we get a much greater quantity of electricity, and the effect is quite as striking as the other way in which we were working. Here I have two specimens of glass jar, which were on the table when I was speaking about differences of potential in my first lecture. One is the thick piece of glass 1 inch in diameter, which was pierced by a spark from Mr. Spottiswoode's machine. The other piece not so thick, about ½ inch, has been pierced by a spark from a machine you see before you. It is very beautiful to see the nature of the discharge through the glass. Here I have half-a-dozen of Abel's fuses which I will explode all together in series. I will now show you, as we have this apparatus on the table, the very beautiful form of discharge by Mr. Gassiot's tubes. This jar has the conductor from the top passing through an insulated tube down into the interior of a tumbler where the terminal consists of a flat disc of metal. The other pole is another flat disc on which the tumbler, as I may call it, is supported. The tumbler itself is of fluorescent glass and adds to the beauty of the appearance, and the discharge, therefore, cannot pass through the glass directly from pole to pole, but has to mount up over the lip of the cup or tumbler.

[Several other experiments were shown illustrating the beautiful colours of electric discharge in rarefied atmosphere with fluorescent glass.]

Miscellaneous.

PROPOSED INDIAN AND COLONIAL INSTITUTE.

H.R.H. the Prince of Wales has addressed the following letter to the Lord Mayor:—

Marlborough-house, Pall-mall, S.W.,
Sept. 13th, 1886.

Dear Lord Mayor,—My attention has been frequently called to the general anxiety that is felt to commemorate in some special manner the approaching jubilee of her Majesty's reign.

It appears to me that no more suitable memorial could be suggested than an Institute which should represent the Arts, Manufactures, and Commerce of the Queen's Colonial and Indian Empire.

Such an Institution would, it seems to me, be singularly appropriate to the occasion, for it would illustrate the progress already made during her Majesty's reign in the Colonial and Indian Dominions, while it would record year by year the development of the Empire in the arts of civilisation.

It would thus be deeply interesting to her Majesty's subjects both within and beyond these islands, and would tend to stimulate emigration to those British territories where it is required, to expand the trade between the different British communities, and to draw closer the bonds which unite the Empire.

It would be at once a Museum, an Exhibition, and the proper locality for the discussion of Colonial and Indian subjects.

That public attention has already been forcibly directed to these questions is sufficiently proved by the remarkable success which is attending the Colonial and Indian Exhibition at South Kensington, and I confidently anticipate that arrangements may be made whereby the more important collections, which have so largely contributed to this success, will be placed at the disposal of the Institution.

I have much satisfaction in addressing this letter to your Lordship as Chief Magistrate of the capital of the Empire, and to invite your co-operation in the formation of this Imperial Institute of the Colonies and India, as the memorial of her Majesty's jubilee by her subjects.

Should your Lordship concur in this proposal, and be willing to open a fund at the Mansion-house, I would suggest that the contributions received be vested in a body of Trustees, whom the Sovereign would be asked to nominate, and I would further suggest that the Institution should be under the permanent presidency of the Heir Apparent to the Throne. I remain, dear Lord Mayor,

Yours truly,

ALBERT EDWARD P.

The Right Hon. the Lord Mayor.

The Lord Mayor's answer to the Prince of Wales's letter is as follows:—

The Mansion-house, London, E.C.,
Sept. 17th, 1886.

Sir,—I have the honour to acknowledge the receipt of your Royal Highness's letter of the 13th inst., and, in reply, to express the great pleasure it will afford me to give the heartiest co-operation and aid in the formation of the proposed Imperial Institute of the Colonies and India as the memorial of her Majesty's jubilee by her subjects.

Your Royal Highness truly states that general anxiety is felt to commemorate in some special manner the approaching jubilee of her Majesty's reign. There will, I am sure, be a universal desire to give expression, in a suitable and, if possible, adequate way, to the deep attachment, veneration, and loyalty which the Queen's subjects in all parts of her vast dominions entertain for a Sovereign whose long and illustrious reign has been productive, under Providence, of many blessings to her people and been rendered memorable by the striking progress in civilisation and prosperity developed throughout the Empire.

Difficult as it may be to signalise in a commensurate way the feelings which are thus naturally emphasized at the approach of the jubilee of her Majesty's reign, I am convinced that the proposal which your Royal Highness indicates, and which has the support of your influence, will be considered singularly appropriate.

It will, therefore, give me much satisfaction to open a fund at the Mansion-house for the receipt of contributions, as suggested by your Royal Highness.

I have the honour to remain, Sir, with the greatest respect, your Royal Highness's most dutiful and most obedient servant,

JOHN STAPLES, Lord Mayor.

His Royal Highness the Prince of Wales, K.G.

THE PRODUCTION OF AMBER IN GERMANY.

Her Majesty's Consul at Königsberg, in his last report upon the trade and industries of that port, states that amber, which from earliest periods has been one of the chief productions of the Königsberg coast, and which was formerly chiefly picked up on the shore, or floating on seaweed in the sea, is now sought for by mining operations at Palmnicken, and by dragging at Schwarzort, and by diving operations at both places. The mining operations are in the hands of a company, and have been carried on for more than twenty years. In the time of Frederick the Great, mining operations were also attempted, but they were not sufficiently successful, on account of the mines not being carried deep enough, and they were abandoned. The present company pays the Prussian Government £100,000 a year for the right to mine. The amber is found in this way in great abundance, and it is said that the prices during last season did not vary very much. Large pieces fetched from 13 marks to 120 marks, and small pieces from 25 pfennings to 13 marks per kilogramme. One piece, weighing 7 lbs., was found in the course of the past season, and a piece of 11 lbs. weight was found a year or two ago, by mining, which is the largest piece found since the days of Frederick the Great. The quantity of amber obtained by steam dragging at Schwarzort, in 1884, amounted to 1,300 cwts., as compared with 1,230 cwts. in 1883; by mining at Palmnicken and Kraxtepellen to

2,920 cwts. against 2,000 cwts.; by diving, 160 cwts. were obtained in 1884, compared with 150 cwts. in 1883; and the quantity found by dragging, straining, &c., amounted to 100 cwts. in 1884, as compared with 90 cwts. in the preceding year. The quantity therefore found in 1884 was greater than that obtained in 1883, by 110 cwts. The amber trade, however, says Consul Stigand, has been suffering considerably of late by the quantity of the imitated article which has been thrown on the market, and imitation amber has largely taken the place of real amber, in the manufacture of pipes. This, it is stated, has been especially the case in Vienna, where pipes are manufactured in large quantities. In the dragging operations at Schwarzort about 900 men are employed; in Palmnicken, during the summer, about 1,000, and 120 divers in addition. There is a special railway to the mines of Palmnicken, and steam engines are employed to the amount of about 1,400 horse-power.

PATENT-OFFICE REPORT.

The Report of the Comptroller-General of Patents, Designs, and Trade Marks, for the year 1885, has just been issued. The number of applications for patents during the year was 16,101, a falling off of 1,009 only from the number (17,110) applied for in 1884, the first year of the new Patent Act. Of this total, 11,695 were made through agents (about 73 per cent.), the remainder, or 27 per cent., being made directly to the Patent-office by the applicants themselves; 77 per cent. of the total applications were made from persons resident in the United Kingdom; 112 applications for amendment of specifications before the sealing of the patent, and 61 applications for amendment after sealing, were made at the Patent-office. Of these 173 applications 120 were allowed by the Comptroller, 13 were refused, 4 were withdrawn or abandoned, and 36 were not dealt with during the year. During the year, 4,383 notices of similarity of inventions applied for were given in respect of 2,531 applications, and 49 applications previously included in prior applications were reported. About 120 under Section 94 (which provides that a personal hearing shall be given to the applicant before refusal) were heard by the Comptroller. Only a single application, and that an informal one, was made for a compulsory licence. The number of readers who frequented the library during the year 1885 was 44,176, against 39,508 in the previous year. The number of designs registered during the year amounted to 20,388, exclusive of 337 "sets" of designs. The term "set" includes any number of articles ordinarily on sale together, irrespective of the varieties, of the size, or arrangements in which the particular design may be shown on each separate article. The total number of applications for trade marks during the year (including 115 applications to the Cutlers' Company) was 8,026, as compered with 7,104 in the year 1884. The total receipts of the office amounted to £88,509, the payments being £77,740, leaving £10,769 surplus income.

FORESTS OF ALSACE LORRAINE.

The United States Consul, at Kehl, says that the forests of Alsace Lorraine cover an area of 1,109,660 acres, representing about 36 per cent. of the whole territory. The most important are situated in the Vosges Mountains, the highest peak of which is the *Ballon de Guebwiller* towering to a height of 4,300 feet. The importance of the forests of Alsace Lorraine is very considerable, they are the richest of all the forests of France, and are now only excelled in Germany by the forests of Baden. As regards the ownership, 336,000 acres are held by the Government; 42,955 by the Government and various communities; 496,040 by communities, and 234,665 by private individuals. Of the 336,000 acres owned by the Government, 51,522 acres are situated in Upper Alsace; 100,380 in Lower Alsace; and 184,098 in Lorraine. By Government, is to be understood the Government of Alsace Lorraine, and not the Imperial Government at Berlin. While Alsace formed part of the possessions belonging to France, they were managed by the district officers at Colmar, Strasburg, Metz, and Nancy. The officers who were under the supervision of the central forest administration had under them inspectors, sub-inspectors, and chief foresters. The subaltern officers were foresters, guards, and auxiliary guards. The whole forest service consisted of 4 conservators, 18 inspectors, 22 sub-inspectors, 37 chief foresters, and 330 foresters. After the annexation of Alsace Lorraine to the German Empire, the French division into three or four districts was maintained, the higher positions being filled by Germans, while in the inferior places the Alsatians who occupied them before the war were retained. Upon the establishment of a separate Government for Alsace Lorraine, under Field-Marshal von Manteuffel, the administration of the forests was attached to the Treasury Department of Alsace Lorraine. The trees chiefly grown are oak, beech, pine, fir, birch, and elm. All the trees have a beautiful growth, notwithstanding the stony soil. The beech tree represents 33 per per cent. of the entire forest production, and this tree is cultivated at all heights. The oak is generally planted on the plains. Among the evergreens the fir tree is the most important, covering 34 per cent. of the Alsatian forests, and next in importance is the pine, which thrives best in the plains. The woods, where large trees and undergrowth are mixed together, cover an area of 377,887 acres. There are 90,485 acres of undergrowth alone. Chestnut tree groves have an area of 10,920 acres, and these which only thrive well in sheltered valleys, are found chiefly in Lower Alsace. All the forests, no matter to whom they belong, are placed under the supervision of the forest administration, and the latter regulates the cutting of the timber. Owners even of private forests are not allowed to cut down their own wood without the consent of the Government. The forests are regularly estimated in order to determine the exact yield. For the cutting and replanting of a forest in the Vosges a period of 120 years is required. The Government of Alsace Lorraine own extensive saw mills, which can be used also by private individuals on payment of a fee of sixteen shillings per 1,000 feet. The wood is sold by public auction. The chief forester is allowed to sell small quantities of wood, never exceeding about forty-five shillings in value, to the same person in one year. For larger amounts he must receive a special authorisation from his superiors. Since 1871 the area of the forests has increased to the extent of 3,300 acres, 2,332 of which were for Government forests, and during this period 2,370 acres have been cleared. The wages of wood cutters vary considerably, in autumn from one shilling to two shillings and sixpence a day; in spring from one shilling and threepence to three shillings, while during the time of felling, wages are at the rate of three shillings and sixpence a day. The receipts obtained from the Government forests in Alsace Lorraine amounted in 1884 to a total of £40,300, and this is exclusive of the amounts derived from hunting. Hunting is either rented to private persons or carried on by foresters. The amounts produced by letting to private persons averages £1,560 for 147,500 acres, or about twopence an acre. The average annual expenditure for the maintenance of the forests is about £125,000.

RAILWAYS, POST-OFFICES, AND TELEGRAPHS OF WURTEMBURG.

Her Majesty's Secretary of Legation at Stuttgart, in his last report, says that the length of the permanent way open for traffic on the State railways in Würtemburg was, on the 31st March, 1884, 958 miles, showing a slight increase as compared with the total length at the end of March, 1882. The small Freudenstadt-Schiltach line, measuring about 15 miles, and which is in course of construction, will, it is expected, be finished and opened for traffic in a few months; in this case, the total length of State railways would amount to 973 miles. Of the present lines, 46 miles are situated in the Grand Duchy of Baden, 5 miles in Bavaria, 37 in Prussia, and 870 in in Würtemburg. The total number of stations of all sorts under Wurtemburg administration amounted, in 1884, to 202, and the total number of servants and *employés* to 8,133; these numbers show a slight increase over former years. The rolling stock of the State railways in 1884 consisted of 331 locomotives, together with 298 tenders, 798 passenger carriages, to seat 36,818 persons, and 5,147 goods trucks, to carry 48,951 tons. The total cost of the rolling stock is calculated at £2,012,762, and is composed as follows:—For locomotives and tenders, £869,471; for passenger carriages, £291,442; and for goods trucks, £851,849. The list of accidents for 1883–84 amounts to 90 in all, showing an increase of 10 as compared with 1882–83. Of this number, only 3 passengers were killed, and seven wounded; 17 railway officials were killed, the rest were wounded, giving an average per 1,000,000 passengers of ·26 killed and ·62 injured. The total number of passengers conveyed during the years 1882-82 and 1883–84, were respectively 10 388,941 and 11,373,804; of these, in the former year, 11·66 per cent. travelled first-class; 19·04 second-class; 29·70 third-class, and 26·63 in composite carriages, and in the latter year, 11·40 travelled first-class; 15·60 second-class; 31·57 third-class; and 26·63 per cent. in composite carriages. The goods traffic in 1883–84 amounted to 2,761,291 tons, and the traffic in cattle amounted to 135,099 tons; in coal to 606,342 tons, and in boats running in connection with the railways to 1,490 tons. The receipts derived from passengers were £468,590, and from goods £861,223. After deducting certain items from the gross receipts and expenses, the net expenditure for the year 1883–84 amounted as follows:—Receipts, £1,453,091; working expenses, £771,091; leaving a surplus of £682,000. The expenses of administration can thus be calculated at £51·12 per cent. of the receipts, as compared with 53·7 per cent. in the year 1882–83, and 53·2 per cent. in 1881–82. The net receipts represent 3·07 per cent. of the gross capital, as compared with 2·79 per cent. in 1882–83, and 2·86 per cent. in 1881–82. The total number of postal establishments in Würtemburg on the 31st March, 1884, amounted to 537, or three more than in the previous year. A postal establishment serves on an average 36,320 square kilometres and 3,671 inhabitants. The number of places selling postage stamps was 958, or 62 more than in 1883. Of the number of letter-boxes, 1,092 were placed in post towns, and 1,972 in country places, or in all 3,064, an increase of 23 over the previous year. The total number of post-office *employés* in 1884 amounted to 4,260, and of telegraph *employés* to 1,449, or in all 5,709. The number of letters posted in Würtemburg during the year 1884 amounted to 39,718,440, and the number of those received for addresses in this country to 40,671,432, which gives an average of a little over 20 per head of the population. The total number of newspapers, both sent and delivered during 1884, is put down at 30,216,417 copies, or at the rate of a little over 15 per head of the population. The total number of parcels, money and different valuables, which were despatched in the country during the year 1884 amounted to 5,036,580, and the number of the same articles received for addresses in Würtemburg amounted to 4,496,292, or an average of 2·3 per head of the population. The total value of Post-office orders paid in and out of Würtemburg during the year 1884, amounted to £12,300,000, giving an average of 33s. 6d. per head of the population. The total number of State telegraph offices in 1884 was 414, composed as follows:—389 in Würtemburg territory, 15 in the State of Baden, 8 in Hohenzollern, and 2 in Bavaria. This gives an average of one telegraph office to every 47·2 square kilometres, and to every 4,773 inhabitants. The length of the telegraph lines had increased from 1,706 miles on the 31st December, 1881, to 1,723 miles on the 31st March, 1884. The total number of telegrams of every description received, sent, or transmitted during the year 1884, was 2,036,125, or 49,120 more than in the previous year. The communications by telegraph only date from the year 1881, and the total number of telephones working in the kingdom of Würtemburg on the 31st March, 1884, is given at a little over 200, with a length of wire of 151 miles. The gross results of the State posts and telegraphs for the year 1884, were as follows:—Gross receipts, £319,431; gross expenditure, £247,957; surplus, £71,474. This surplus, with a few other items accruing to it, amounted actually to £72,069, and, after deducting a 4 per cent. interest on the original and working capital, the net receipts for the year amounted to the snm of £55,101.

DISTRIBUTION REFORM.

Mr. H. J. Jenkinson has put forward a scheme for bringing the producer and consumer together without the intervention of so many middlemen or distributors of produce as at present. Mr. Jenkinson, in the first place, brought his views under the notice of the Postmaster-General, and of the Secretary of the Royal Commission on Depression of Trade and Industry, but as neither of these officials were able to deal with the matter, he now suggests that the scheme should be carried out by a limited liability company. The scheme is described by Mr. Jenkinson as follows:—

"Agents of the company to be employed in every town and village, who can receive orders for any articles of commerce. The orders to be accompanied with a deposit of the price and cost of carriage, &c. The agent will then communicate direct either with the manufacturer or with the agent residing where the orders are to be executed, and the article required will be sent either direct to the purchaser or to the agent through whom the order was given.

"For this service rendered by the company a percentage upon the price of the purchase will be included in the amount deposited.

"The per-centage charged by the company on all orders for goods, as sole middlemen between the producer and the consumer, can be arranged on any workable basis: say, five per cent. for orders of £5 and under, with no less charge than 6d.; above £5 and not more than £10, four per cent.; above £10 and not more than £20, three per cent.; above £20 and not more than £50, two-and-a-half per cent.; above £50 and not more than £100, two per cent.; above £100, one per cent.

"The per-centage required to pay the company, as compared with the present retail trade, will be very small, for the expenses will be comparatively light, the whole being a ready money business, requiring no dead stock, bad debts, or high rents, and only a limited number of servants.

"The first requisite for carrying out the scheme would be a directory containing the names and addresses of all manufacturers and wholesale firms. This would be useful to the general public, and could be produced so as to realise a profit."

FOREST DISTRIBUTION OF THE UNITED STATES.

In the United States, exclusive of Alaska, the district of Columbia, and the Indian territory, there are thirty-eight states and eight territories, making a total of forty-six. The superficial area of these amounts to 2,900,107 square miles, or 1,856,070,400 acres. The total forest area is 489,280,000 acres, or 26·4 per cent. of the superficial area. The Director of the United States Department of Agriculture, says that the group of states and territories lying west of the ninety-fifth meridian, viz., Arizona, California, Colorado, Dakota, Kansas, Montana, Nebraska, Nevada, New Mexico, Oregon, Texas, Utah, Washington, and Wyoming, have an area of 1,900,159 square miles, or 1,216,101,600 acres, which is 65·5 per cent. of the whole area of the United States, with the exceptions above noted. The area of forests in this group, exclusive of the Indian territory, is only 184 800,000 acres, or 15·2 per cent. of the superficial area. Excluding California, Montana, Oregon, Texas, and Washington, which contain the largest proportion of woodland, the superficial area of the remaining states and territories of the group would be 751,776,000 acres, being 40·5 per cent. of the whole of the country, only 59,800,000 acres, or 8 1 per cent. of which is in forests. The group of States, thirty in number, lying east of the ninety-fifth meridian, have an area of 1,000,000 square miles, or 640,000,000 acres, being 34·5 per cent. of the whole area; 304,280,000 acres, or 47·5 per cent. of which is in forests. The Eastern and Northern States, forming a part of this group, namely, Maine, New Hampshire, Vermont, Masschusetts, Rhode Island, Connecticut, New York, New Jersey, Pennsylvania, Delaware, Maryland, West Virginia, Ohio, Indiana, Illinois, Michigan, Wisconsin, Minnesota, Iowa, and Missouri, have an area of 313,547,200 acres, 139,180,000 of which, or 44·4 per cent., is in forests. The Southern States, forming a part of the group east of the ninety-fifth meridian, namely, Virginia, Kentucky, Tennessee, North Carolina, South Carolina, Georgia, Florida, Alabama, Mississippi, Arkansas, and Louisiana, have an area of 326,421,600 acres, 165,100,000 of which, or 50·6 per cent., is in forests. While the section, or group of states west of the ninety-fifth meridian, contains 65·5 per cent. of the whole superficial area, it contains but 37·8 per cent. of the forest area of the country; and the group east of the ninety-fifth meridian, while it contains but 34·5 per cent. of the whole superficial area, contains only 62·2 per cent. of the area of the forest. The group of nineteen Eastern and Northern States contains 16·9 per cent. of the total superficial area, and 28·4 per cent. of the forests. The group of eleven Southern States contains 17·6 per cent. of total superficies, and 33·8 per cent. of the whole forest area of the United States. The Western group contains 889,680 acres of superficial area, or 272·6 per cent. more than the Southern group, and only 197,000,000 acres, or 4 per cent. more of forest area.

LIGHT AND WATER-COLOURS.

Mr. William Simpson records in the *Times* of the 13th inst. the results of an experiment in which washes of colour have been exposed for fifteen years, and portions of the same wash preserved from the light, so that they can now be compared. The list embraces thirty-one pigments, including the most of those generally used by water-colour artists. The washes were made in stripes upon cards; and the cards afterwards were cut in two, so that the exposed and unexposed tints could be compared exactly where they were separated. The exposed slips were pasted on a sheet of paper, and placed in a frame, which was hung on a shutter of a window with an east light. Here they remained for fifteen years.

The following is the list of colours, with Mr. Simpson's remarks: — Yellow ochre — unchanged. Indian yellow — has faded considerably. Lemon yellow—is not perceptibly affected. Gamboge—has faded. Newman's permanent yellow—unchanged. Cadmium yellow—this has not faded, but has seemingly become of a browner tinge. Chrome yellow—faded considerably; the slip not exposed seems to have become more orange, but, unfortunately, I had not noted at the time which chrome had been used. Brown pink—has faded, but it has stood better than might have been expected from its reputation. Emerald green—scarcely changed. Burnt sienna—unchanged. Vandyke brown—unchanged. Sepia—this shows a very slight tendency to fade. Roman sepia—this may have faded also, but, like the common sepia, the change is not very perceptible. Burnt umber—unchanged. Bistre—unchanged. Brown madder—this colour has lost a little of its redness. Light red — unchanged. Vermilion — shows no change. Indian red—unchanged. Crimson lake—this colour has all but disappeared from the paper; at one side where the colour was laid on deeper a brown streak still remains. Carmine—this, like the lake, has entirely gone, but where the carmine was laid on deeper, a faint brown streak is still left. Madder lake—this colour has stood well, but it is now a little less red, and more of a purple. Purple madder—like the other madders this has stood, but seems to be changed very slightly in tone. Cyanine blue—seemingly unchanged. Prussian blue—unchanged. French blue—very slightly faded. Cobalt—I can detect no change in this valuable pigment. Ultramarine is, of course, unchanged. Newman's azure—is unchanged. Indigo—where there was a rather deep wash of this colour the exposed slip shows now an exceedingly light tint of grey; in fact, it has nearly left the paper white, but has not vanished so completely as the crimson lake and the carmine. Lamp black—unchanged.

Correspondence.

CANAL NAVIGATION.

The article from the *Engineer*, lately condensed in your *Journal*, makes some allusion to the long period (say six months) during which ice renders the Erie Canal useless. This alone is quite enough to prevent the competition between that waterway and the railways forming any test of the relative merits of the two kinds of carriage. It has also to be remembered that the large cost of the canal is due to its present size having been attained by successive enlargements. There is also the rivalry of the St. Lawrence, &c., to consider.

Two dimensions only of some British locks are given, though the third (depth) is wanted to form some idea of the tonnage that can be passed at one time.

An examination of many foreign transport statistics has led me to believe that in Britain, a boat of about 250 tons might carry, on an artificial waterway, under average conditions, for about ⅔d. per tone-mile; and, on an improved river (say the Lower Severn) for about ⅓d. per ton-mile; making the cost of transport, half on a river, half on canal, about ½d. per ton-mile. The waterways, however, must be in non-commercial hands if the public is to benefit to this extent.

WALTER M. T. CAMPBELL.

It is announced that an Exhibition of the products and manufactures of the Philippines will be opened at Madrid, on the 1st April, 1887.

Notes on Books.

THE GAS ENGINEER'S CHEMICAL MANUAL. By J. Alfred Wanklyn. London: Scientific Publishing Company. 1886. Sm. 8vo.

This little book is intended primarily as a help to those whose business it is to test illuminating gas, and also to give the general public an insight into the various processes for the manufacture of gas. The first chapter is introductory, the second is devoted to coal, the third to coal-gas, the fourth to tar, the fifth to ammoniacal or gas liquor, the sixth to coke, and the seventh to the purification of gas.

INTERNAL TRANSIT. By Sir Arthur Cotton, Dorking. 1883. Sm. 8vo.

This pamphlet contains particulars respecting the canals of this country, and an attempt to show the need for a re-consideration of the whole subject of transit in England. The author writes, "It is one of the most remarkable things in present progress that while there is nothing in which such extraordinary improvement has been made as in ocean transit, internal water carriage has been almost stationary, ... I have no doubt that had a hundredth part of the thought that has been applied to land carriage of late years, been brought to bear upon internal water carriage, England would have been benefited to the extent of sixty or eighty millions a year."

THE LIFE AND LABOURS OF JOHN MERCER, F.R.S., F.C.S., THE SELF-TAUGHT CHEMICAL PHILOSOPHER. By Edward A. Parnell, F.C.S. London: Longmans, Green, and Co. 1886. Sm. 8vo.

It is now nearly twenty years since Mr. Mercer, the technical inventor and chemist, died, and both his sons (each of whom intended to write the life of his father) have died within this period. The task of writing his life has now been performed by Mr. Parnell. John Mercer was born in 1791, and began life as a bobbin winder, and afterwards was employed as a hand-loom weaver. He taught himself the art of dyeing, and soon became connected with the Oakenshaw Print Works, in which concern he was subsequently a partner. His first practical knowledge of chemistry was obtained from James Parkinson's Chemical Pocket-book, 1803, which introduced him, he said, into a new world. He soon afterwards commenced those discoveries of applications of chemistry to the art of dyeing and calico-printing, which made him celebrated. One of his processes was named after him, "Mercerising." He was a juror at the International Exhibition of 1851, and in the following year he was elected a Fellow of the Royal Society. The appendix to this book contains some recipes for colour preparations in use at the time of the dissolution of partnership, which have not previously been published.

Obituary.

PROFESSOR BARFF. — Frederick Settle Barff, M.A., died at Buckingham, on the 11th August, in the sixty-third year of his age. Mr. Barff delivered before the Society of Arts, in 1870, a series of Cantor Lectures on "Artistic Colours and Pigments." At this time he held the office of Assistant Professor of Chemistry at University College, London. It was owing to the attention drawn to the subject of these lectures that the chair of Chemistry was founded at the Royal Academy, and that Mr. Barff was appointed the first Professor. Professor Barff delivered a course of Cantor Lectures, in 1872, on "Silicates, Silicides, Glass, and Glass Painting;" and another, in 1874, on "Carbon, and Certain Compounds of Carbon, treated principally in reference to Heating and Illuminating Purposes." He also gave the Juvenile Lectures for 1878, on "Coal and its Compounds." For his paper on "Zinc White as Paint, and the Treatment of Iron for the Prevention of Corrosion," read in 1877, Mr. Barff received the Society's medal. In this paper he announced the discovery of his method of protecting iron from rust by producing a film of magnetic or black oxide of iron on the surface of the metal. In March, 1879, he read a second paper on his process for "The Treatment of Iron to Prevent Corrosion." In 1882, he obtained another medal for a paper on a "New Antiseptic Compound, and its Application to the Preservation of Food." Mr. Barff served as examiner in Chemistry for the Natural Science Tripos at Cambridge, and held the office of Professor of Chemistry to the Catholic University at Kensington, and in the Jesuits' College, Beaumont. He was elected a member of the Society of Arts in 1870.

SIR JOHN KELK, BART.—Sir John Kelk, of Tidworth-house, Wilts, a member of the Society of Arts since 1859, died on Sunday, 12th inst., in his 71st year. He was the son of the late Mr. John Kelk, of St. Anne's, Westminster, by his marriage with Martha, daughter of Mr. Jacob Germain, of Bloomsbury, Middlesex, and was born in 1816. The firm of Lucas and Kelk were the contractors for the Exhibition of 1862, and when it was evident, at the close of the Exhibition, that the receipts would not suffice to cover the expenses, not only did the firm forego certain of their claims, but Mr. Kelk placed a sum of £11,000 at the disposal of the Commission, in order to prevent the necessity of a call upon the guarantors. He was a magistrate and deputy-lieutenant for the county of Middlesex, a major in the Engineer Volunteer Staff Corps, and he sat in the House of Commons in the Conservative interest as member for Harwich from 1865 to 1868. He was created a baronet in 1874, and served as high sheriff of Hampshire in 1884.

General Notes.

Commercial Museums in Belgium.—Commercial museums have been formed at Charleroi and at Liège. At Liège the museum is to be divided into two sections, the first embracing articles of import with a statement in each case of their origin, their price at the port of shipment, cost of transport, custom duties, and conditions of sale. The second section will be devoted to articles in demand in foreign markets, together with particulars as to the packing of the goods and conditions under which they can be delivered to the purchaser.

Metallurgy.—The Session of the Evening Class Department of King's College, London, will commence on October 4th. 1. A course of lectures on "The Properties of Metals and Alloys, and their Uses in the Arts" will be given on Monday evenings, from 8 to 9 p.m., and will include the study of the various metals in common use. Especial attention will be devoted to the metallurgical requirements for the examinations of the City and Guilds of London Institute in Metal Plate Work, Plumbing, and Iron and Steel. 2. A course of lectures will also be given by W. G. McMilan on "Fuels; their Uses and Economy," on Monday evenings, from 7 to 8 p.m., and will include the subjects required for the City and Guilds Institute Examination in Fuel. 3. A class of Practical Metallurgy will be held on Fridays from 7 to 9 p.m., in the Metallurgical Laboratories, to enable students to become practically acquainted with the properties of Metals, and the general methods of Assaying and Mechanical Testing, &c.; and also, if they desire it, students may prepare for the Examination of the Science and Art Department in Practical Metallurgy. There are a few free admissions to Classes 1 and 3; those desirous of obtaining them should apply at once to Professor Huntington, at the College, stating fully the grounds on which their claim is based.

Parkes Museum.—A course of lectures and demonstrations for the instruction of sanitary inspectors will be delivered at the Parkes Museum on the Mondays, Wednesdays, and Fridays, in October, from the 4th to the 29th, at eight p.m. The introductory lecture will be on "General History, Principles, and Methods of Hygiene," by Dr. G. V. Poore, and the following lectures have been arranged as follows:—2. "Water Supply, Drinking Water, Pollution of Water," by Prof. W. H. Corfield, M.D. 3. "Drainage, Construction," by Prof. H. Robinson. 4. "Sanitary Appliances," by Mr. Percival Smith. 5. "Ventilation, Measurement of Cubic Space, &c.," by Prof. F. de Chaumont, M.D., F.R.S. 6. "Scavenging and Disposal of Refuse," by Mr. H. Percy Boulnois. 7. "Food, good and bad, Milk, Sale of Food and Drugs Act," by Mr. C. E. Cassal. 8. "Infectious Diseases and Methods of Disinfection," by Dr. R. Thorne Thorne. 9. "General powers and duties of Inspectors of Nuisances. Method of Inspection," by Mr. J. F. J. Sykes. 10. "Nature of Nuisances, including Nuisances the abatement of which is difficult," by Mr. J. F. J. Sykes. 11. "Sanitary Law—General Enactments, Public Health Act, 1875, Model Bye-Laws," by Dr. Charles Kelly. 12. "Metropolitan Acts, Bye-Laws of Metropolitan Board of Works," by Mr. A. Wynter Blyth. It is proposed to repeat the course twice each year, to suit the requirements of persons preparing for the Examinations of the Sanitary Institution of Great Britain; the lectures will comprise all the subjects scheduled for those examinations.

Woollen Manufactures in Japan.—Although it appears that there is no probability of wool being grown in Japan, as the only sheep in that country are animals reared with great trouble as curiosities, it is said that woollen manufactures will probably be carried on to advantage there. The Japanese of the upper classes are very generally adapting European clothing, and though this is now principally made by native tailors, all the cloth comes from abroad, especially from Vermont and other New England States. Woollen fabrics are being used very extensively amongst the rich, and before long the same articles bid fair to become popular with the poorer people. The Japanese Government and nation see that there is a fair field for starting woollen manufactures in their country, and, taking into consideration the imitative faculties of this people, and the low rate of wages at which they are content to work, they are likely soon to become proficient in manufacturing too, if they can get the wool, especially as they have shown themselves to be capable of using machinery and other aids to labour which twenty years ago were unknown to them. If wool could be imported, a great industry might be established. The wool of New Zealand and Australia is said to be more suitable than that grown in America for manufacturing cloth for Japan, on account of its greater fineness, and as this latter country has so many products, such as tea, sugar, and rice, all of which are marketable commodities in Australasia, the commercial relations between Japan and those colonies, it is thought, might be developed advantageously by a mutual exchange of produce.

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All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

Proceedings of the Society.

CANTOR LECTURES.

THE MICROSCOPE.

By John Mayall, Jun.

Lecture V.—Delivered December 21, 1885.

Achromatic Microscopes (Continued).

I have said that the application of achromatism to microscopes by Tully, in England, appears to have at once shown the need of better mechanism, and that he commenced the improvement by applying steadying rods to the body-tube, and mechanical movements to the stage. Then, as the apertures of the objectives were increased, and the focal planes became correspondingly shallower, it became necessary to apply a more sensitive system of focussing than any previously employed.

Cuff's system of a direct-action screw moving the socket-support of the body-tube, which Martin adapted to act on the socket-support of the stage, fell into disuse for compound microscopes, and during many years was superseded by the rack-and-pinion motion variously applied. The Cuff-Martin system was still used as far as the early years of this century for simple microscopes, such as Jones's "Pocket Botanical and Universal Microscope," where two or three single lenses were pivoted on a pillar, to act singly or together over a stage and mirror, which differed from Ellis's Aquatic Microscope only in minor points, contrived specially to render the instrument more portable.

In Cuthbert's Reflecting Microscope we saw the Cuff-Martin focussing screw applied to the stage; and in Chevalier's "Microscope Universel" a similar, though improved, arrangement was employed; and in Schiek's microscope, Pistor's, and Ploessl's, I have stated that inferior plans, somewhat similar, were persisted in during several years, when far more accurate and better focussing systems were generally known.

On the Continent, the direct-action screw seems to have found much favour, and it would not be difficult to select from the microscopes that are known a series directly converging to the plan employed by Oberhaeuser; but we have other matters to engage our attention.

In England, the Cuff-Martin focussing screw was not much used with achromatic microscopes; indeed, it may be said to have died out with Cuthbert's Reflecting Microscope. Our opticians began by improving the rack-work, so that great precision of focussing movement was thus attained, a precision which has, on the whole, been steadily maintained down to our own time, and which the American opticians—judging from the rack-work of Tolles, Zentmayer, Grunow, Bulloch, Bausch, Lomb, and others that I have examined—have at least equalled. But, however well the rack-work was made, still more sensitive means were required for focussing, and the opticians attacked the problem with much energy. An immense number of devices resulted, some of which are bizarre in the extreme as well as ingenious; in others the ingenuity has been tempered by distinctly practical aims, and in a very small minority of cases the practical aims have been so well supported by mechanical skill and experience, that great success has been attained.

Among the bizarre contrivances for fine adjustment, there is one arrangement which I notice on account of its singularity, and because it is one of the most recent, and devised in the face of our modern systems as if in defiance of all the experience, optical and mechanical, of which we stand possessed; I allude to D'Arsonval's system of water focussing, where the fine adjustment is effected by pumping more or less water into a specially arranged body-tube. Other bizarre systems have consisted principally in the applications of cat-gut to actuate the mechanism, or, again, of levers of extraordinary length acting on the body-tube, causing it to tilt towards or from the object. This latter system has had (and still has) its equivalent in systems employed by Amici, and Nobert, and others, where the stage has been made to tilt upwards or downwards, *i.e.*, obliquely in relation to the optic axis, by the action of a screw, the upward motion being sometimes due to the spring of the bent stage-plate itself (as in one of Amici's models), or to a spiral-spring raising the stage-plate on a hinge; and in some cases —notably in Nobert's model—the stage was suspended on two points serving as pivots, and a lever beneath, acted upon by a screw passing through the pillar, caused the upward motion, the reverse motion acting by gravity alone, so that, in practice, the position of the microscope was intended to be vertical only. These and analogous contrivances were mostly designed to economise the expense; from any other point of view they cannot be approved.

A less objectionable plan was devised (by Oberhaeuser, I believe, but I have met with it in microscopes of early date by C. Chevalier, and by Pritchard – in the latter case bearing strong evidences of Chevalier's workmanship), where the stage-plate was raised or depressed at right-angles to the optic axis, by a direct-acting screw, with or without the combination of a spiral-spring encircling it within a sheath.

Our earliest real designers of fine adjustments for the compound achromatic microscope, James Smith, Andrew Ross, and Hugh Powell (I purposely exclude Cornelius Varley, for, in my opinion, most of his contributions to the mechanism of the microscope bordered so much on the bizarre, that their influence has rather retarded than advanced the best points of construction), seem to have been undecided as to the best position for the fine adjustment; hence we find very early, and apparently contemporaneous, efforts made to apply the movement to the nose-piece by a conical-ended lifting screw, and to the stage by means of a moving frame with three wedges, acted upon by a screw, variously placed (for which mechanism Powell was awarded the Silver Isis Medal by the Society of Arts in 1834). Or, again, modifications of Oberhaeuser's system were tried, either by a screw acting directly on the sheath-support of the body-tube, or in combination with a short lever at the back, or the screw passed through the tail-piece, and the actuating milled head was at the end. In these latter modifications Powell does not seem to have taken part; his best early models had the fine adjustment applied to the stage, as I have noted, and it is only justice to him to admit that, as a focussing movement, his mechanism acted with great precision—a precision hardly surpassed at the present day.

At this early period the best microscopes were made of what would now be regarded as unwieldly size—veritable monuments of mechanism. Smith and Ross built up their great models without any apparent intention of simplifying the movements. We find mechanical stages of six or eight inches diameter, and two or three inches in thickness, with controlling pinions projecting horizontally two or three inches laterally, or at the back, or shortened somewhat, and applied vertically beneath by means of brackets or angle-pieces, the arrangements defying description. In some of Powell's models we find his "Turrell" stage-mechanism with two screw stage-micrometer movements acting at right angles, and the focussing movement all combined in one stage.

I cannot determine who first applied the fine adjustment to the nose-piece. I have met with very early models by Powell, with a conical-ended screw lifting the nose-piece by the contact and movement of the coned surface; and he appears to have tried various positions for the actuating screw, placing it even near the eye-piece. Ross appears to have tried the plan now known as "Jackson's" fine adjustment earlier than 1835, according to the recollection of some opticians I have met, who were connected with the manufacture of microscopes at that date; and he appears also to have mounted the socket-carrier of the body-tube on a strong stem with rack, bent in the middle to provide space for a large stage, and continued beneath the stage, in a manner quite analogous to that known as the "Jackson" form.

It seems to be generally admitted that Ross devised the plan of carrying the body-tube on the end of a hollow cross-bar on the top of, and at right angles to, the rack-stem, which was planned to enable him to use his system of fine adjustment consisting of a fine screw with large milled head, acting by a point on the long arm of a lever, the short arm of which ends in a fork in contact with a stud on either side of a cylindrical sliding-tube, forming the nose-piece of the body-tube in which the objectives are screwed; a spiral-spring presses down the nose-piece, and it is against this pressure that the screw and lever act.

This system appears to be the first really sensitive focussing applied to the nose-piece; and it was, and probably still is, the most delicate system ever applied to the microscope. It has had a long period of popularity, and it still survives applied to Powell and Lealand's microscopes, which are generally considered, by experts in the use of the microscope, to stand alone in their excellence for all purposes where extreme exactness and delicacy are needed.

The rival system of fine adjustment—the short lever and screw applied externally to the body-tube—known as the "Jackson" system, which seems to have been contrived to allow the body-tube to be supported more substantially on the limb or stem, has had its merits ably realised in the microscopes of Smith and Beck and their successors, and by Tolles, of Boston, and, except as modified by the present firm of Ross (Schroeder's form, which we shall examine later on), I believe the consensus of opinion among the experts in manipulation is that it has been superseded by other plans applied to the "Jackson" form of microscope.

As I could not illustrate the various phases of the development of these fine adjustments without far more time and space than could be properly assigned for the purpose, I have thought it advisable to pass over this period with these general remarks, and come at once to the best typical example evolved by the combined efforts of Ross and Powell, and shall, therefore, ask your attention to Powell and Lealand's microscope; premising, however, that it represents not only the best points of construction devised by Andrew Ross, but other and better points added or modified by Messrs. Powell and Lealand. We shall examine several phases of construction of the "Jackson" form later on, and compare them incidently with this microscope.

Powell and Lealand's Microscope.—In this instrument (Fig. 78, p. 1098) we have a broad tripod base, forming the most substantial support ever devised for a microscope without unduly increasing the weight; the position of the horizontal (inclining) axis is such that the balance of the instrument is well maintained from the vertical to the horizontal.

The coarse adjustment is effected by rack on a large prismatic stem, moving within a sheath or box through the front of which passes the horizontal axis; on the top of the stem is attached the cross-arm carrying the body-tube—the cross-arm enclosing the lever-mechanism for the fine adjustment, as devised by Andrew Ross. This cross-arm is much longer than that used by Ross, and thus carries the body-tube more forward, so as to provide radial space for the complete rotation of the stage on the optic axis, while, at the same time, the lever of the fine adjustment is lengthened, and greater delicacy of motion is secured without rendering the actuating screw or other parts of the focussing mechanism too fragile for long service.

The stage has mechanical movements on the "Turrell" system, which Powell first constructed for Edmund Turrell, and for which the Society of Arts awarded a medal in 1832; it also rotates completely on the optic axis by means of an obliquely placed pinion acting on a bevelled rack on the inner face of the stage-ring, supporting the mechanism. "Finders" are engraved on the plates, and the main support of the stage-ring is graduated for angle measuring, a pointer on the ring marking the amount of motion in arc.

The sub-stage is carried by rack-work, and has rectangular centering movements, supporting an inner socket that can be rotated by rack-and-pinion, in which sub-stage apparatus is placed. In the latest models, a fine adjustment by screw-cone and stud is applied by means of an extra slide in front of the rack slide.

The mirror (plane and concave) is mounted in a half-gimbal, with two arms and a socket sliding and rotating on the tail-piece, and a clamp-screw fixes it where required.

The stage is attached to the sheath of the stem by a special arrangement of screws, by which the rotation in the optic axis can be centered; and sliding spring-clips, and a removable and adjustable angle-piece to hold the slides, are applied on the upper surface.

The body-tube is pivoted to move laterally on the top of the stem, and an adjustable steel stud beneath serves to stop the movement in the axis.

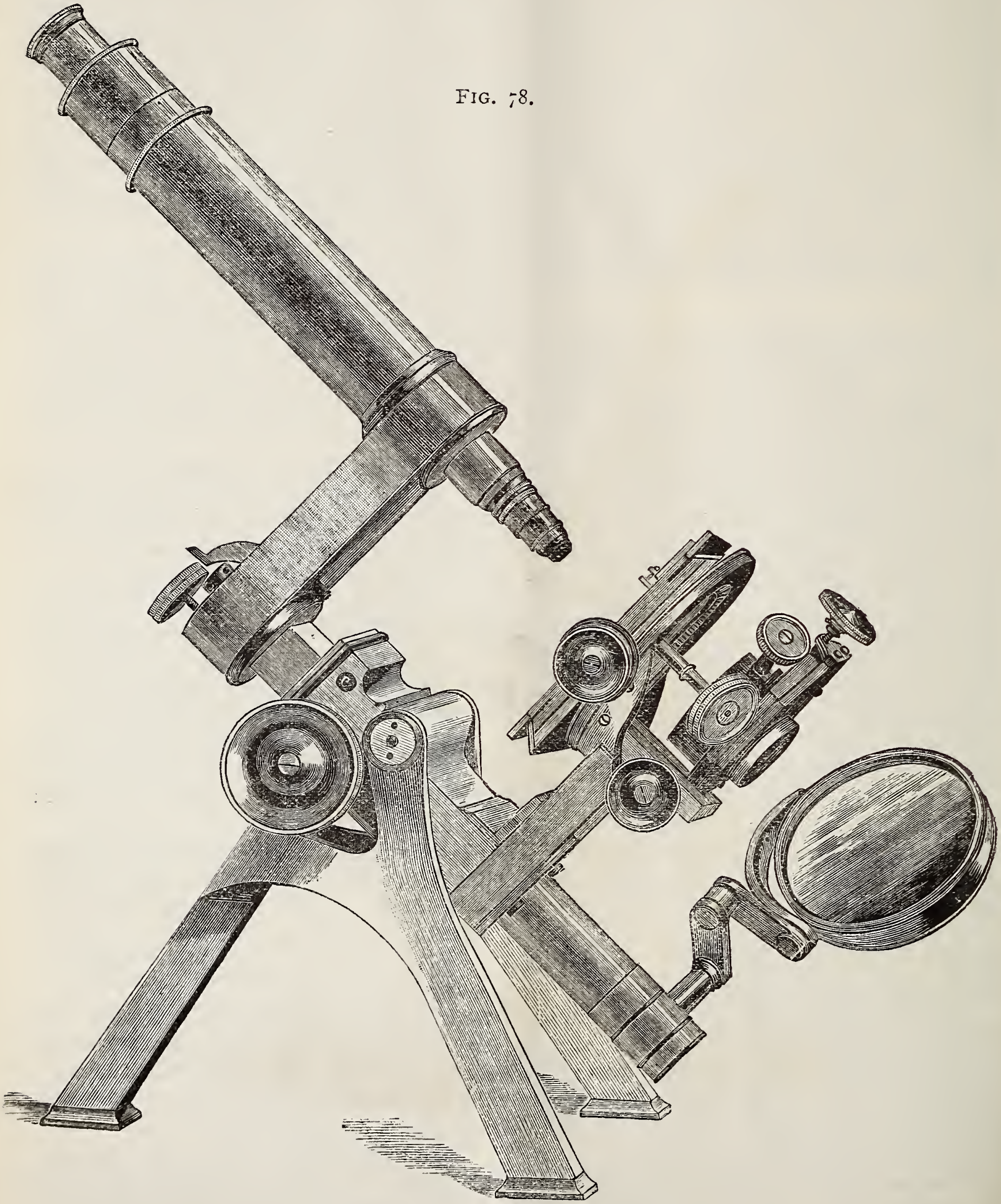
In venturing to note upon what I consider to be points where improvement might be made in the design of this microscope, I feel that I must be—

> ". . . . careful of my motion,
> Like the skater on thin ice that hardly bears him,"

for it represents the result of nearly fifty years steady devotion to the perfecting of the instrument by Powell and Lealand, embodying at the same time the best ideas of mechanism and design by Andrew Ross.

I find the mechanism of the stage movements always in a condition of flexure, due to the system of superposed plates sliding in grooves; and I think some such system as that I have suggested (Fig. 75, see *ante*, p. 1079) would get rid of the flexure, especially if the surface of the rotating stage-ring were of glass, without in any way diminishing the command over the movement of the object-slide. By dispensing with the moving plates, the thickness of the stage would be considerably reduced, and the arrangement would be available for supporting some useful form of oblique illuminator—preferably on the homogeneous-immersion system—not needing other adjustments than could be easily combined with its own fitting; or again, allowing the ready application of a simple system of graduated diaphragms, stops, &c., to be used *above* the sub-stage condenser.

FIG. 78.

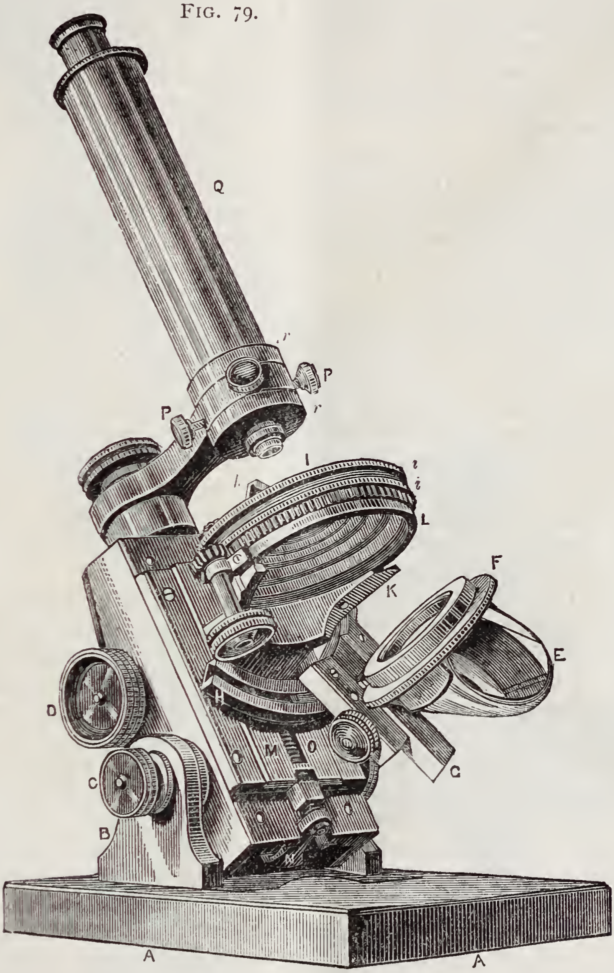


POWELL AND LEALAND'S MICROSCOPE.

Before we come to the other English and American microscopes designed to compete with Powell and Lealand's as instruments of the highest class, I must note that they have all been very considerably influenced by the construction of Zentmayer's "Centennial" Microscope, exhibited at the Philadelphia Exposition, in 1876, in which the tail-piece was arranged to swing laterally on an axis, in a line cutting the optic axis in the plane of the object on the stage. Zentmayer's idea was, I believe, quite original so far as he was concerned, though, in fact, it was a revival of Jones's system, shown in Fig. 64. Singularly, too, the idea had been realised in a different manner by the late Thomas Grubb, in a microscope he devised in 1853, patented in 1854, and which he improved in 1858, and described firstly in vol. v. of the "Proceedings" of the Royal Irish Academy, and secondly (the improved form) in a paper communicated to the Royal Dublin Society, 26th March, 1858.

Grubb's Sector Microscope.—In this microscope (Fig. 79) the principle of radial illumination was shown in the application of a grooved sector, H *h*, in which the lenticular prism, E, is moved by hand through any required arc concentric with the object on the stage, so as to provide illumination at all obliquities in altitude: the rotation of the toothed wheel, L, by means of the pinion and milled head presenting the object to the illumination in all azimuths.

FIG. 79.



GRUBB'S SECTOR MICROSCOPE.

I is the stage; *i i*, upper and lower milled rings, which produce, on being turned by hand, the slow motions in two directions of the object-plate of the stage.

M is a dovetailed slide carrying both stage and sector, with the illuminating prism. A screw and its bent lever (the latter passing to the back of the instrument) are partially shown at N; and at O is a spiral-spring which keeps the slide, M, in close contact with the screw, N. The body-tube is mounted in a centering ring controlled by the screws, P P.

This microscope appears to have passed

almost wholly unnoticed in England until about 1880. As a working instrument, I should say there are very few points in it that would now commend themselves for imitation. In my opinion, however, for the purpose of radial illumination, Grubb's sector is a more serviceable system than that employed by Zentmayer. With the sector, the adjustment of the illumination can be effected without causing the image to sway about in the field, because the illuminator is practically free from contact with the stage; but with Zentmayer's swinging tail-piece, suspended, as he devised, on a tubular sheath through which the conical axle-support of the stage passes, every touch on the mirror or substage is translated into unsteadiness in the image.

Zentmayer's "Centennial" Microscope.—This microscope (Fig. 80, p. 1101) was contrived by Zentmayer, of Philadelphia, to provide greater facilities for oblique illumination, by mounting the sub-stage and mirror or arm suspended as I have just described.

The fine adjustment is effected by means of a second slide, behind the slide of the coarse adjustment, which is acted upon by a lever (within the bent limb) and screw. This system of fine adjustment which acts sensitively only in the vertical direction, and does not respond to the backward motion of the screw where the instrument is inclined to the horizontal—the downward motion acting by gravity only—was employed by Grunow, in a microscope which I examined more than ten years ago, and which had then been made several years. The principle of making the delicate-fitting slides of the fine adjustment bear the weight and rough usage of the "Jackson" coarse adjustment, seems to me wholly defective. No arrangement of this kind that I have examined would bear any critical testing.

As to the particular mechanism of the swinging tail-piece contrived by Zentmayer, I have already said that I regard it as inferior to Grubb's sector arrangement.

With this microscope, Zentmayer supplied two extra stages, one with mechanical and rotary movements, the other of special thinness, with rotary movement only, for diatom work. The workmanship is excellent, as also that of the "Tilghman" friction-stage shown in the figure. The mechanical stage, however, is so contrived that the rotating plate is mounted on the top of the plate actuated by the mechanism of the rectangular movements, so that the rotation has no direct correspondence with the optic axis; that such an arrangement should have been devised for a modern instrument entering the lists as a first-class miscroscope, is another item which I cannot approve.

Bulloch's "Congress" Microscope (second form).—In this instrument (Fig. 81, p. 1102) Bulloch improved upon Zentmayer's design, by attaching the stage to the limb by an angle-piece, so as to be free from the tail-pieces, of which two are applied, one for the sub-stage, and one for the mirror.

The arrangement for carrying the lamp, so that the illumination can be moved concentrically with the object on the stage should be compared with that shown in Jones's Radial Swinging Tail-piece (Fig. 64).

Bulloch modified Zentmayer's fine adjustment by applying a box-fitting to the slide, and by adjusting a spiral-spring to give the downward motion; but the arrangement is utterly vitiated by carrying the coarse adjustment on the front of the delicate slides of the fine adjustment.

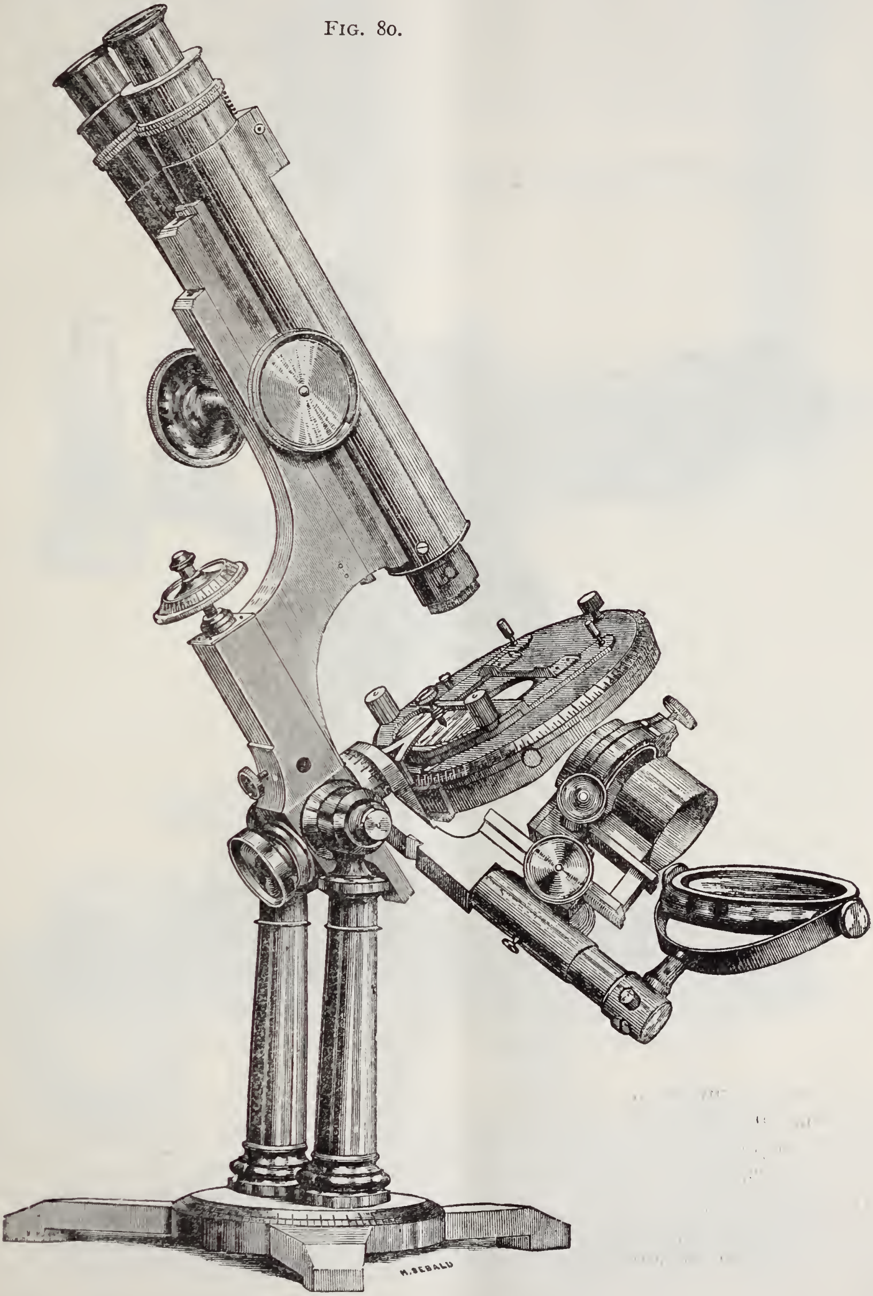
Tolles's Microscope with Vertical Disc.—In this microscope (Fig. 82) Tolles mounted the stage on a disc, the centre of which corresponds with a line cutting the optic axis in the plane of the object on the stage. Near the edge of the disc the substage travels in a groove, carrying the condenser in arc round the object as a centre, in a manner analogous to that shown in Grubb's Sector Microscope (Fig. 79).

For obtaining radial illumination on the object, this arrangement of Tolles's is an elaboration of his Traverse Substage, which I have long regarded as the best practical accessory apparatus that has been applied for the purpose. Some of the details of the construction, which depend to a great extent on the application of the disc, do not commend themselves to me; for example, I find the narrow zone on which the substage is supported far too weak, and the attachments and general mechanism of the substage are too slight, so that the centering-screws, diaphragms, &c., cannot be touched without betraying flexure.

In later constructions of this form of microscope, Tolles applied a mechanical stage acting by two plates about 1-50 inch in thickness, actuated by two pinions vertical to the surface of the stage. By this arrangement of the pinions, the movements were effected entirely within the circumference of the stage, so that a complete rotation of the latter was obtained without the necessity of carrying the body-tube more forward. In previous constructions of the

"Jackson" form, the rotatory movement of a large mechanical stage, with lateral projecting pinions, had always been stopped on either side by the limb.

FIG. 80.



ZENTMAYER'S "CENTENNIAL" MICROSCOPE.

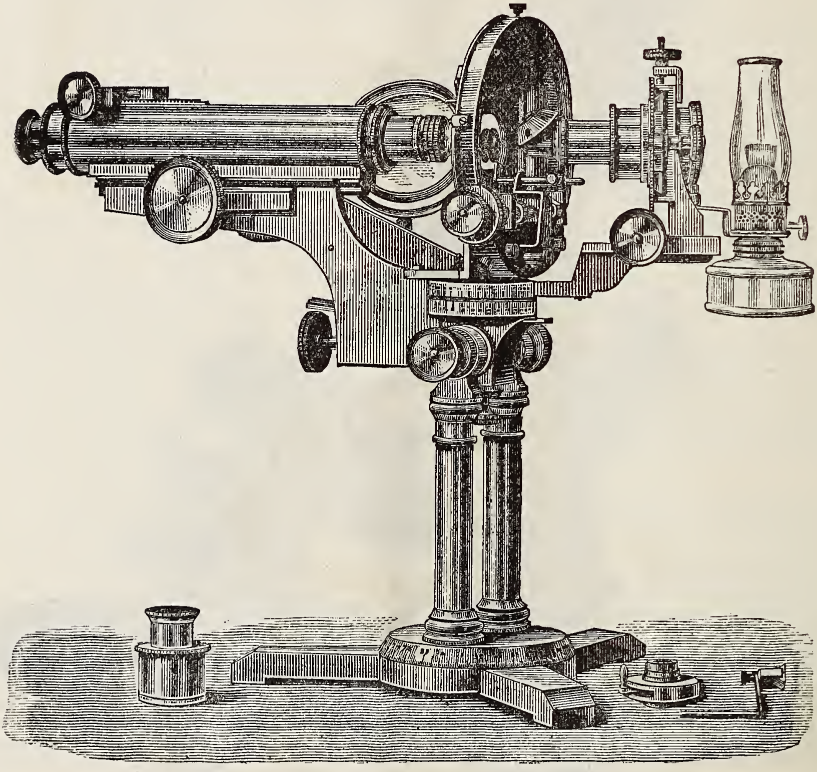
When this stage was examined by Mr. Wenham, he at once proposed to improve the mechanism by removing the lower of the two plates, and by combining the pinions on one axis—a modification of the "Turrell" form—which we shall see adopted in the Ross-Wenham Radial Microscope. Tolles also worked out practically the same system; but, as a matter of fact, he was preceded by Mr. Wenham. In Tolles's later form he gave greater rigidity to the stage by adding a flange to the upper edge that gradually increased in thickness towards the shoulder by which the stage was attached to the vertical disc; by this arrangement the stage remained very thin—hardly more than 1-8 inch—and the under surface was plane, so that the manipulation of apparatus beneath was as free as possible. Swift and Son have adopted this plan of strengthening the stage in one of their recent models.

In Tolles's later microscopes we find an extra radial arm mounted on a second disc, behind the large one, to carry the mirror; this was applied as a ready means of condensing light on the surface of the stage, or for utilising a second beam of light for particular resolutions.

Tolles devised many arrangements for oblique illumination; his best apparatus of this kind was the "Traverse Substage," which consisted of a graduated semi-circle of brass, having a hemispherical lens applied slightly below the centre of the arc, and in a zonal groove near the edge a carrier is fitted to slide and carry a small condenser. This contrivance is made to rack in the place of the usual substage, and the hemispherical lens is adjusted in immersion contact with the base of the slide; then the movement of the condenser in the zonal groove from the axis to near the horizon of the hemispherical lens gives the required obliquity of illumination, slight touches of the mirror directing the light through the condenser. Tolles also applied a system of prisms to this device, so as to reduce the amount of adjustment required of the mirror; and he added other hemispherical lenses of different radii for use with various classes of work; a special arrangement of collimated diaphragms was also adopted for measuring angles of aperture by means of a lamp or candle carried in the zonal groove. In the most complete form of this apparatus, he applied two socket-carriers for condensers, placed about 45° apart, and in one example I have seen, the intention was to dispense with the ordinary stage of the microscope, and employ the Traverse Substage alone.

With careful manipulation, it is possible, with this apparatus, to register the precise obliquity

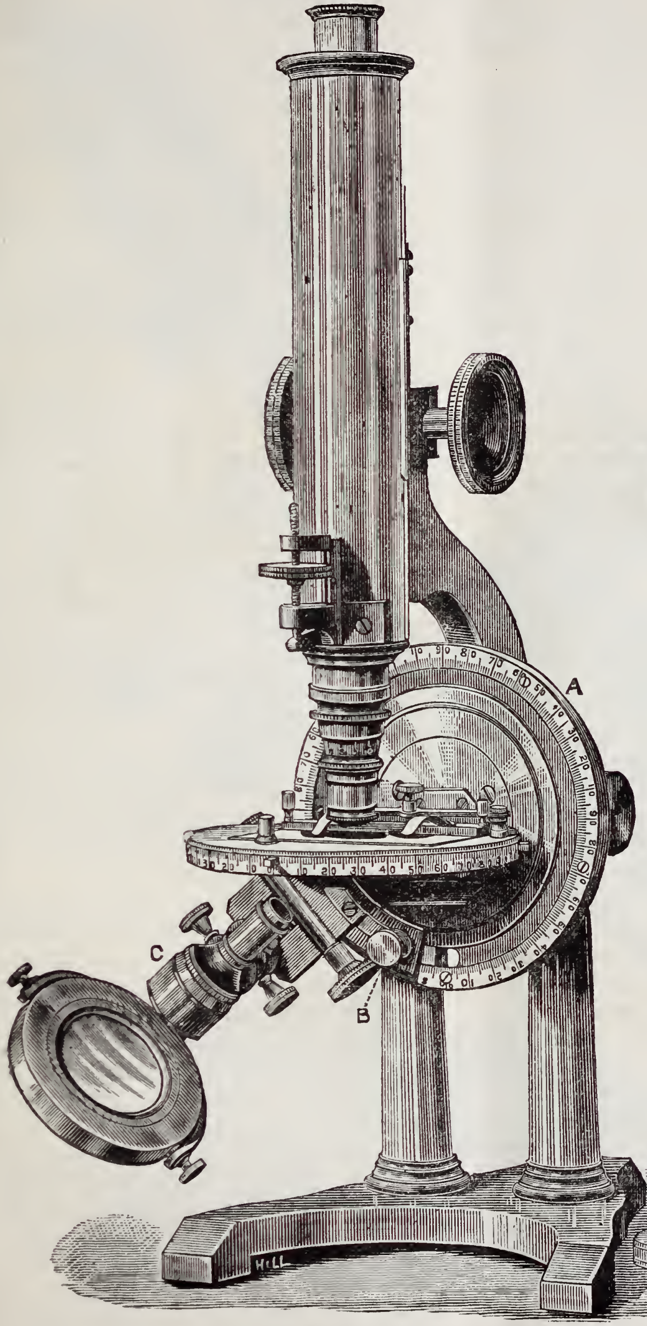
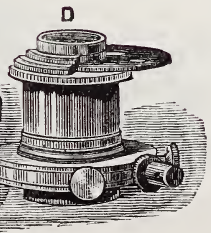
Fig. 81.



Bulloch's "Congress" Microscope (Second Form).

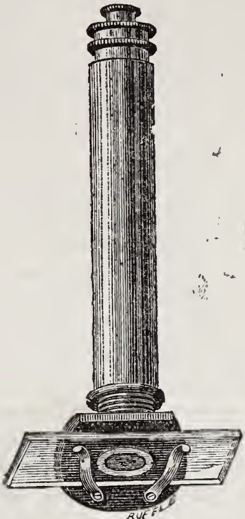
of illumination requisite to obtain a series of fine resolutions, and thus to repeat the experiments exactly. With such an apparatus one could determine how nearly we have approached the theoretical limit of resolution for each extension of aperture in our objectives, under given conditions of illumination, and viewing fine rulings like Nobert's Test-plates. By making photographs with careful registrations of the whole conditions, we should have the problem demonstrated beyond dispute. The general application of this form of Traverse

Fig. 82.

Tolles's Microscope with Vertical Disc.

Fig. 83.



Tolles's Clinical Microscope.

Substage as an accessory apparatus would wholly supersede Zentmayer's swinging tail-piece and similar contrivances.

The body-tube and fine adjustment of Tolles's best microscopes were of the "Jackson" form; I may, therefore, say a few words on the comparative merits of this and of the Powell and Lealand form.

From my point of view, the choice of one or the other form, considered as microscopes of the highest class, must necessarily turn on the question of the best fine adjustment. With equally good fine adjustments, the preference will certainly be given to the "Jackson" form, on account of the greater stability of the body-tube, and the less liability to injury. Every other point of excellence in the Powell and Lealand form is perfectly applicable to the "Jackson," or to well-known modifications of it. Assuming that Tolles made the "Jackson" form as well as any other optician of our time—and his skill in workmanship did not fear rivalry—then the fine adjustment, not being at all comparable in delicacy and precision with that of Powell and Lealand, I am forced to the conclusion that it is not the workmanship that is at fault, but the principle.

One of the best manipulators known with the microscope in our time was the late Dr. J. J. Woodward, of Washington, who was frequently pressed to state his objection to the "Jackson" form of instrument His invariable answer was that he had never found the focussing sensitive enough to enable him to use it for photo-micrography with high powers.

Tolles's Clinical Microscope.—A small microscope (Fig. 83, p. 1103) was devised by Tolles for clinical purposes, which seems to me so good in every way that I must ask special attention for it. The objective is screwed on a tube sliding within the one shown, and, for roughly focussing, the sliding motion suffices; for fine adjustment, the sheath is made to turn on a fine screw-thread on a cylindrical tube, which serves also as a socket-carrier for the stage. The compound microscope is here reduced to the simplest form I have met with to be a really serviceable instrument for the purpose in view; and the mechanism is of thoroughly substantial character. The stage fits in the socket-carrier by a short tube, and, for portability, is removed, and a metal cap substituted, to exclude dust from the objective; a tube cap covers the eye-piece. I commend this model to the notice of our opticians.

Beck's "International" Microscope.—In this microscope (Fig. 84, p. 1105) Messrs. Beck have added a movement to Tolles's vertical disc, by which the centre can be raised or depressed to correspond with the thickness of the slide. The stage can also be turned to the inverted position by rack-and-pinion. Whether or not these modifications are of real service I will leave others to decide.

The fine adjustment is modified from that known as Zentmayer's, and is open to the same objection, inasmuch as the delicately fitted slides have to carry the coarse adjustment, body-tube, &c.

Watson's Microscope (Crossley's form).—In this microscope (Fig. 85, p. 1106) we have an innovation in the method of obtaining radial or concentric illumination, designed by Mr. Edward Crossley, F.R.A.S., and constructed by Messrs. Watson.

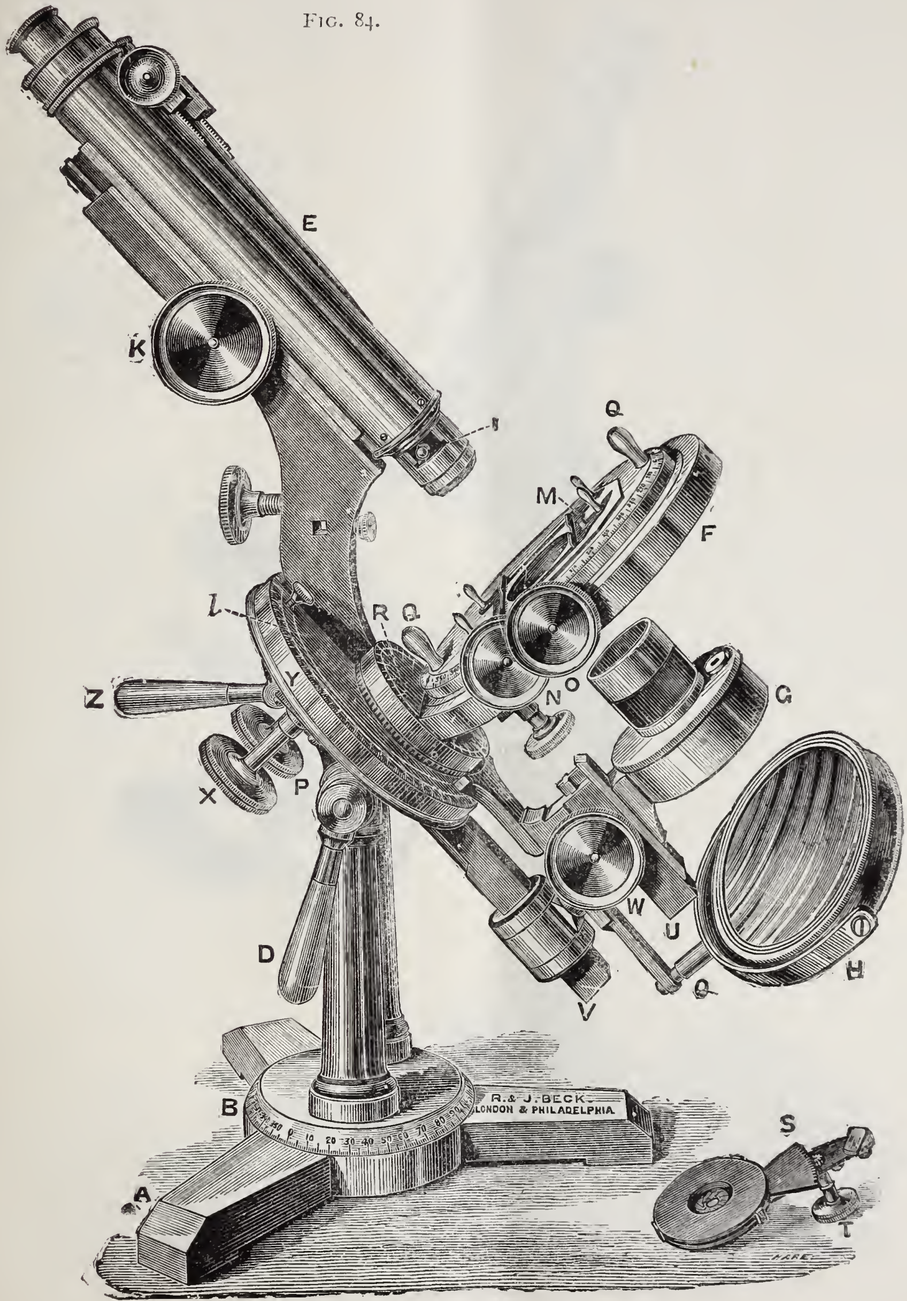
The light from the lamp is projected into the hollow trunnion-axis of the microscope with the aid of a bull's-eye condenser, and by a right-angled prism, A (*vide* Diagram, Fig. 86, p. 1106), placed in the centre of this axis, is reflected forwards in the direction of the axis on which the swinging tail-piece turns. The arm of the swinging tail-piece is made in the form of a box, and carries a second similar prism, B, in the axis on which it moves, so as to intercept the rays of light coming from the first prism and reflect them in the direction of the arm or box. At the other end of the box is a third prism, C, which reflects the rays of light forward on to the mirror, D, whence they are directed to the object, E, on the stage. The dotted line represents the direction taken by the rays after reflection from the prism within the trunnion-axis.

It will thus be seen that no change in position of the microscope on its inclining axis affects the direction of the light from the lamp, and also that in all positions of the swinging tail-piece, whether above or below the stage, the illumination remains constant upon the object. Thus (apparently) the greatest facility is given for illuminating the object at any angle, and seeing which is most suitable.

I have not tested this arrangement of prisms for oblique illumination, and therefore cannot speak of it from personal experience. I should, however, expect such a design to require a general accuracy of construction in the mechanism and in the adjustment of the prisms, quite beyond the average found in our best microscopes.

The swinging tail-piece is mounted on a disc after the manner of Tolles's (Fig. 82, p. 1103), and, to provide space for the box arrangement, the stage is carried on a bent arm so as to be free from the tail-piece. This plan greatly increases the complexity of the manufacture.

Fig. 84.



Beck's "International" Microscope.

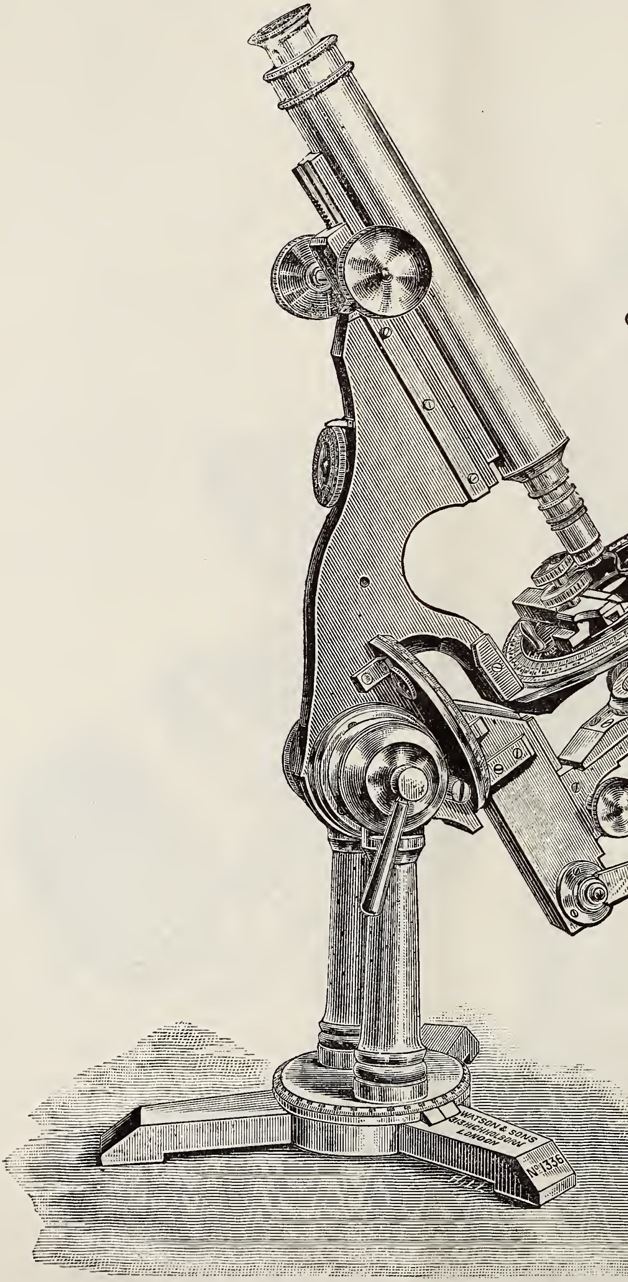
Messrs. Watson appear to have modified the "Zentmayer" fine adjustment by dispensing with the lever, and using a conical-ended screw, lifting the slide by the pressure of the cone-surface. Any such application of the travelling cone—though it were a good system in itself, which I think is not the case—has no beneficial influence on the radically defective method of employing the fine slides to carry the coarse adjustment, &c.

Ross's Radial Microscope (Wenham's

form).—We have here (Fig. 87, p. 1108) a new development in microscope construction due to Mr. F. H. Wenham. The aim has been to provide a large range of effects of oblique light both in altitude and azimuth.

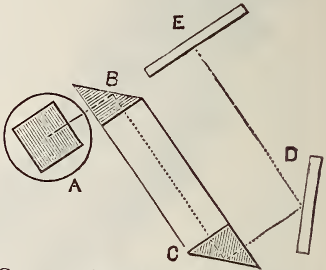
The principal movements are as follows:—

Fig. 85.



Watson's Microscope (Crossley's Form.)

Fig. 86.



Crossley's Swinging Tail-piece with Prisms.

(1.) An inclination of the limb together with the body-tube, stage, sub-stage, and mirror, in a sector sliding within jaws attached to the rotating base-plate. The centre of this inclining motion is (approximately) the point where the plane of the object cuts the optic axis, *i.e.*, a point situated about the thickness of an ordinary object-slide above the centre of the surface of the stage. (2.) A lateral inclination of the limb to either side upon an axis attached to the centre of the sector; the centre line of this axis prolonged forward also intersects the optic axis in the plane of the object on the stage. (3.) A rotation of the instrument on its circular base, the optic axis being the centre of motion.

The leading principle followed in the construction of the stand is that when it is inclined backwards (as in Fig. 88, p. 1109), or laterally (as in Figs. 89, 90, and 91, p. 1109), or rotated on the base-plate, a pencil of light from a fixed source will always reach the object, all the movements, whether separate or combined, radiating from the object (or the prolongations of its axes) as a centre.

The stage rotates completely, and is a modification of Tolles's (to which I referred in my notes on his microscope with vertical disc, Fig. 82), in which the rectangular motions are effected by milled heads vertical to the surface of the stage, and entirely within the circumference. It is mounted on the Zentmayer system, and graduated near the edge, and "finders" are engraved in convenient positions; two centering screws are provided, by which exact rotation on the optic axis can be secured; and it can be easily removed, or may be replaced by a glass or metal friction-stage, &c. A simple and effective plan has been adopted of applying the iris-diaphragm, hemispherical immersion illuminator, &c., beneath the stage, where they are held by a small projecting peg and a spring-latchet.

The sub-stage can be removed entirely from the lower part of the limb by means of a chamferred sliding plate. Rectangular (centering) and rotating motions are provided.

The coarse adjustment is of the "Jackson" form, by means of a spiral pinion and diagonal rack-work.

I will deal with the fine adjustment later.

In illustration of the variety of motions obtained with this microscope, Fig. 88 shows the sector inclined at about the usual position for working with central illumination. Fig. 89 shows the lateral inclination of the limb, &c., the sector being at its highest position. Fig. 90 shows the Zentmayer swinging tail-piece clamped to the sector (as suggested by me), the limb being inclined laterally, and the sub-stage removed; this lateral inclination of the limb causes the stage to revolve upon a central horizontal axis, so as to present the object to the illuminating pencil at all obliquities in altitude, while the rotation of the stage would give illumination in all azimuths. Fig. 91 shows the sector at the lowest point, so that the microscope-body is horizontal, the tail-piece being clamped to the sector, the limb swung laterally about 45° (to the right), and the sub-stage removed; this position of the sector would be that required for measuring angles of aperture by means of the graduations on the circular base. The axis of the lateral inclining motion is also graduated, so that either the degree of inclination of the limb or that of the swinging tail-piece can be registered. In all these positions, and, indeed, in every position in which the various movements enable it to be placed, the microscope is very steady.

Since Figs. 88, 89, 90, and 91 were made, an arm has been attached to a rotating plate in the centre of the lower base-plate to carry the lamp on a pillar, as in Fig. 87.

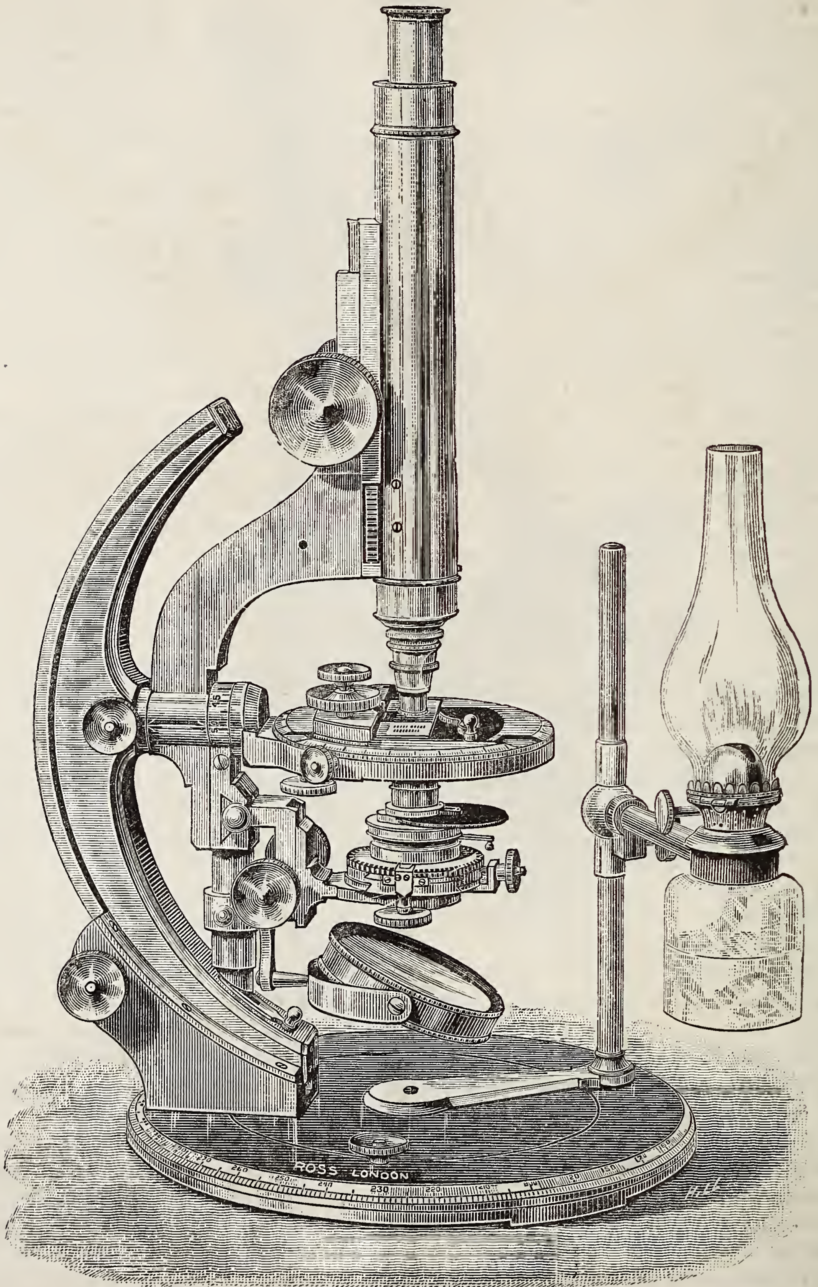
The fine adjustment shown in the four small figures consisted of a vertical chamferred slide, carrying the nose-piece only, and controlled by milled heads on either side of the nose-piece. This arrangement was subsequently replaced by an entirely new design of adjustment by Mr. Wenham, consisting of a **V**-slide, acted upon by two "snail"-cams, between the edges of which revolved a steel roller, forming the axis of, and controlled by, a large milled-head passing longitudinally through the slide of the coarse adjustment, and projecting slightly on either side, in a convenient position for work. The **V**-slide was fitted within the body-tube, and carried at its lower end the nose-piece; it was pressed downwards by a spiral-spring, against which it was moved by the revolution of the cams.

In practice, however, it was found that the steel roller actuating the cams was liable to slip when the movement had not been in use for a few days, and Messrs. Ross engaged Dr. Hugo Schrœder to design a new system, which is shown in Figs. 92 and 93 (p. 1110).

The nose-piece, A, is attached to a tube which is fitted to slide accurately in adjustable bearings in the body-tube, B. The nose-piece tube has a short projecting arm, C, by means of which it is pressed upwards by a strong spiral-spring mounted in a cylindrical box, L, outside the lower end of the body-tube. The arm, C, is moved against the spring by the differential-screw mechanism (with milled head, D), which is gimballed on a bracket, E, attached to the upper part of the body-tube.

The differential-screw mechanism consists of a steel rod, F (connected with D), which has two screw threads at the lower end, one working in a thread cut in the end of the inner tube G, and the other in the block, H, which is soldered within the sheath, J. When the milled head is turned to the left, the block, and with it the sheath, moves downwards, while the rod itself, carrying the block and sheath, moves upwards. As the screws are cut respectively to 45 and 52 threads to the inch, the resultant motion is equivalent to the difference between the motion of the two screws, that is, to the motion of a screw of nearly 335 threads to the inch.

Fig. 87.



Ross's Radial Microscope (Winham's Form)

The end of the sheath is tipped with a small sphere, K, of polished steel, while the projecting arm of the nose-piece tube, against which the end works, has a corresponding concave bed of polished agate.

This differential-screw focussing mechanism was found to work with great delicacy when fitted with extreme care; but the difficulties of manufacture compelled Messrs. Ross to adopt a simplified form, in which a direct-acting screw with a very fine thread is substituted for the differential screw. Experience must decide the question of the durability of this later application of the fine screw; the motion is now so accurate that I am inclined to believe the difficult problem of designing a really efficient and convenient fine adjustment for the "Jackson" form of microscope has met with a solution—at least by approximation. Another solution of this problem has been submitted to me recently by Messrs. Swift, and I must in fairness admit that they, too, have grappled with the difficulty with considerable success; the system is applied in the next microscope we shall examine.

Fig. 88.

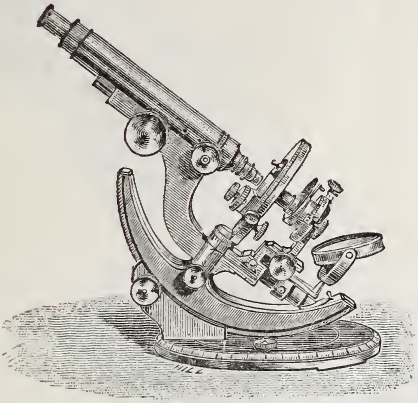
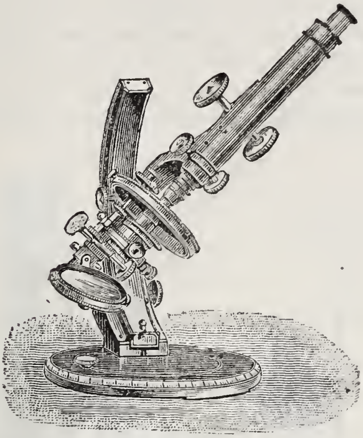


Fig. 89.



Ross's Radial Microscope (Wenham's Form).

Fig. 90.

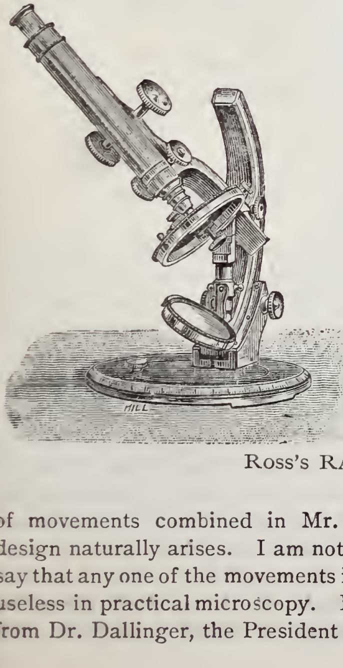
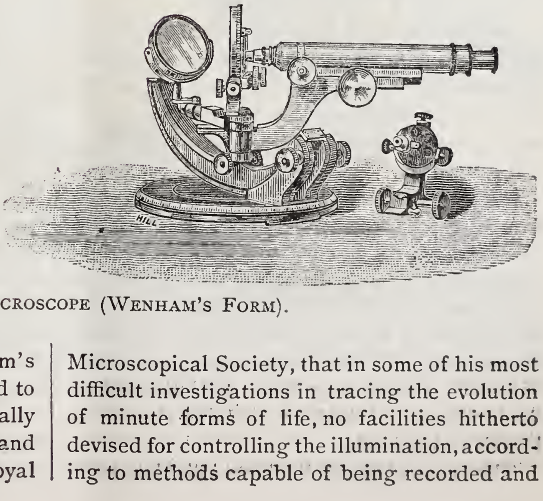


Fig. 91.



Ross's Radial Microscope (Wenham's Form).

The question of the utility of the great variety of movements combined in Mr. Wenham's design naturally arises. I am not prepared to say that any one of the movements is essentially useless in practical microscopy. I understand from Dr. Dallinger, the President of the Royal Microscopical Society, that in some of his most difficult investigations in tracing the evolution of minute forms of life, no facilities hitherto devised for controlling the illumination, according to methods capable of being recorded and repeated, have proved valueless; and I believe he has tested this Radial Microscope by practice more thoroughly than any other microscopist.

In the details of construction, several modifications of Zentmayer's plan of suspending the swinging tail-piece have been introduced by Messrs. Ross, to correct the tendency to flexure and general unsteadiness in the stage and substage so painfully evident in Zentmayer's own construction; and I must admit that my objections to the system of suspension have been correspondingly modified—but no further.

FIG. 92.

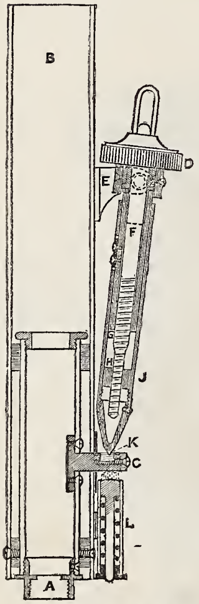
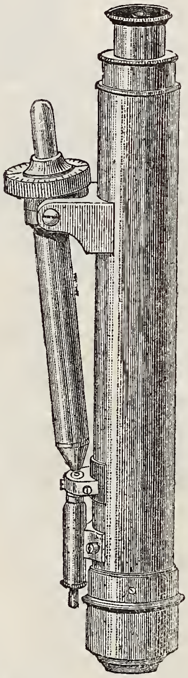


FIG. 93.



SCHROEDER'S FINE ADJUSTMENT.

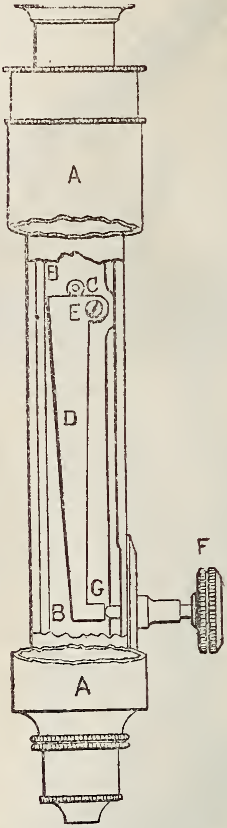
Swift's Microscope (Wale's form).—In this microscope (Fig. 95, p. 1111) Messrs. Swift have adopted a form of inclining limb devised by Mr. George Wale, of the United States, by which great stability in all positions of inclination is secured.

The limb is curved in the lower part in the form of a sector, and on either side a deep V-shaped groove is cut, by which it slides on corresponding projections at the upper ends of the base support; the clamp-screw at the side serves to regulate the tension, or to fix the position. By this arrangement, the centre of gravity suffers very little displacement by the inclination of the limb, and the steadiness is well maintained.

The curve of the limb allows complete rotation of the mechanical stage. The centering and rotating substage is furnished with rack movement, on which it is applied by a dovetailed slide. The mirror, with gimbal, two arms, and rotating socket slides on the tail-piece, which is hinged to swing laterally on the end of the limb.

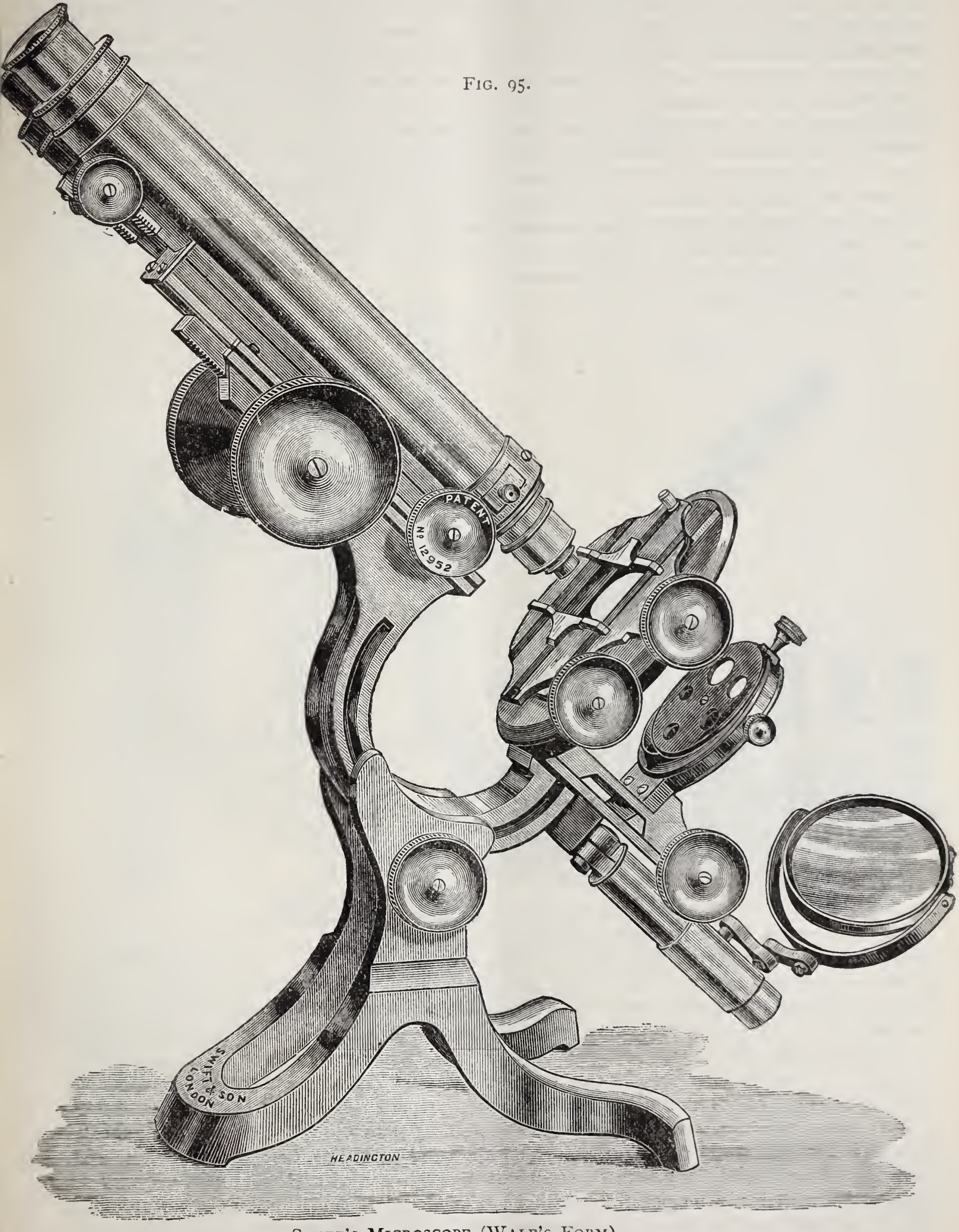
To this instrument Messrs. Swift have applied a new arrangement of fine adjustment which they have patented. The mechanism is shown in Fig. 94, where A A is the body-tube (the middle part cut away to show the action) connected with a chamferred slide at either end at the back, fitted to move accurately and lightly on the front of the coarse adjustment slide, B B, of the usual "Jackson" form, a spiral-spring above and at the back pressing it downwards. A long lever, D, is attached to the plate, B B, to pivot at E; by the action of the milled-head, F, on the lower end, G, of the lever, the lifting stud, C, connected with the chamferred slide behind the bod-tube, B B, is raised very slowly through a focussing range of about 1-10 inch; the

FIG. 94.



SWIFT'S FINE ADJUSTMENT.

FIG. 95.

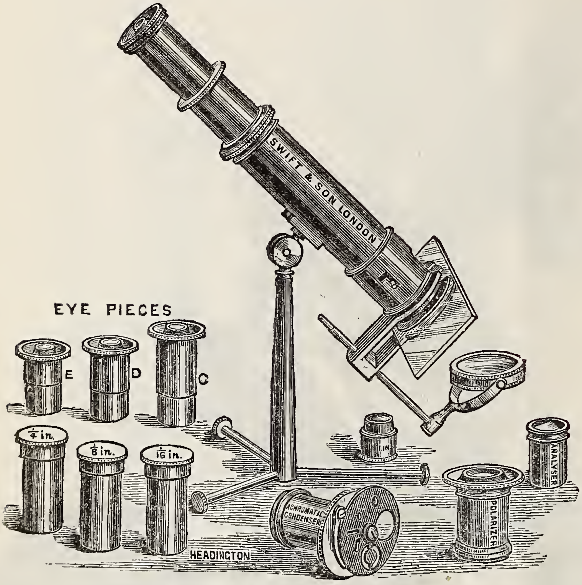


SWIFT'S MICROSCOPE (WALE'S FORM).

reverse action of the screw allows the spiral-spring above to press the slide downwards.

By this very simple mechanism, the fine adjustment is applied on the front of the coarse adjustment, and acts on the whole body-tube, and not merely on the nose-piece, so that the magnification is not altered by change in the focal adjustment. It is obvious that the slowness of the motion is here controlled by three factors: (1) the length of the lever, D, (2) the distance of the lifting-stud, C, from the pivot or fulcrum, E, and the pitch of the screw-thread on F. I am informed that Messrs. Swift anticipate being able to adapt this system of focussing to all their better class of instruments. My trials of this fine adjustment, using a 1-12 inch homogeneous-immersion objective of the highest aperture hitherto constructed (1·5 N.A.) have led me to a decidedly favourable opinion of the mechanism.

Fig. 96.



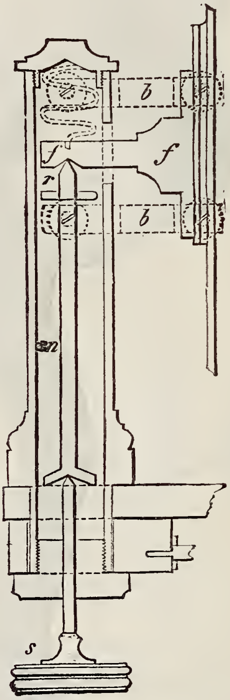
Swift's Portable Microscope.

Swift's Portable Microscope.—Of the many designs of portable microscopes, this little instrument (Fig. 96) is the most complete I have seen, and the workmanship (due, I believe, to Mr. Mansel Swift) is excellent. We have here a compound body with draw-tube fitting with inclining movement on a pillar with tripod base, four eye-pieces, four objectives (including 1-16 inch "immersion,") achromatic condenser with diaphragms, stops, &c., polarizer, analyzer, mirror with gimbal and sliding-rod, the whole fitting in a box of miniature dimensions.

Seibert and Krafft's Fine Adjustment.—For small microscopes the form of fine adjustment shown in Fig. 97 has been much employed in Germany for low-priced microscopes.

The focussing screw, *s*, acts upon the funnel-shaped head of the pivot, *m*, the upper end of which acts in a similar manner upon *ff*, the solid bar attached to the body-tube. The ring, *r*, which serves as a guide-piece, lies loose in the hollow pillar, and, as a rule, does not touch the pivot; its function is merely to prevent the point of the pivot from slipping out of the notch in *ff*. The cross-bars, *b b* (two on each side), are attached by screws to the hollow pillar, and the body-tube is held between the points of four screws near the front ends of the bars. The focussing motion is communicated to the solid bar, *ff*, by the screw, *s*, acting against the pressure of the spiral spring shown above by dotted line, the friction being limited to the eight screws of the four cross-bars. The movement is similar to that of an ordinary parallel ruler with connecting bars, the hollow pillar being the stationary side.

Fig. 97.



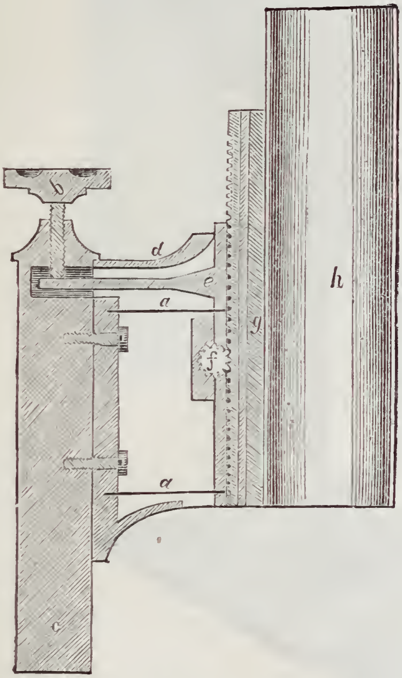
Seibert and Krafft's Fine Adjustment.

In later constructions the four bars have been advantageously replaced by two broad plates.

Bausch and Lomb's Fine Adjustment.—This focussing system (Fig. 98) is probably the simplest that has ever been applied to the compound microscope, and seems to have been suggested by the last we examined.

The focussing screw, *b*, acts upon the angle-piece, *e*, which is connected by rack-work, *f* and *g*, with the body-tube, *h*; *e* is an angle-piece suspended on the pillar, *c*, by the two parallel springs, *a a*. The pressure of the screw, *b*, on *e*, depresses the body-tube, the springs, *a a*, allowing a motion of about 1-10 inch. By the reverse motion of the screw, the springs come back to the normal level as shown.

Fig. 98.



Bausch and Lomb's Fine Adjustment.

A defect in this system seems to have passed hitherto unnoticed. If a high power were in focus with the mechanism nearly in the position shown, a very slight pressure would cause the springs to bend, and thus the objective might break the cover-glass.

Messrs. Beck, Ross, and others appear to have adopted this system for small microscopes, and Messrs. Swift have reversed the movement (to avoid the danger I have noted) by converting the horizontal portion of *e* into a lever suspended on a fulcrum slightly to right of the upper *a*, by which the motion is made slower.

Riddell's Binocular Microscope.—Although personally I do not favour binocular microscopes, yet I think it will be of interest to briefly note upon the chief modern developments in that direction.

Prof. J. L. Riddell, of New Orleans, was the original inventor of the binocular compound microscope with one objective. A copy of his original instrument was recently sent to England, which is shown in Fig. 99 (p. 1114). The arrangement of the binocular prisms is shown in section in Fig. 100 (p. 1115).

The pencil of rays emerging from the objective, *l*, is divided in two, each half passing respectively into the right and left prisms; the path of the rays is *a*, *b*, *c*, *d*, the object is at *o*.

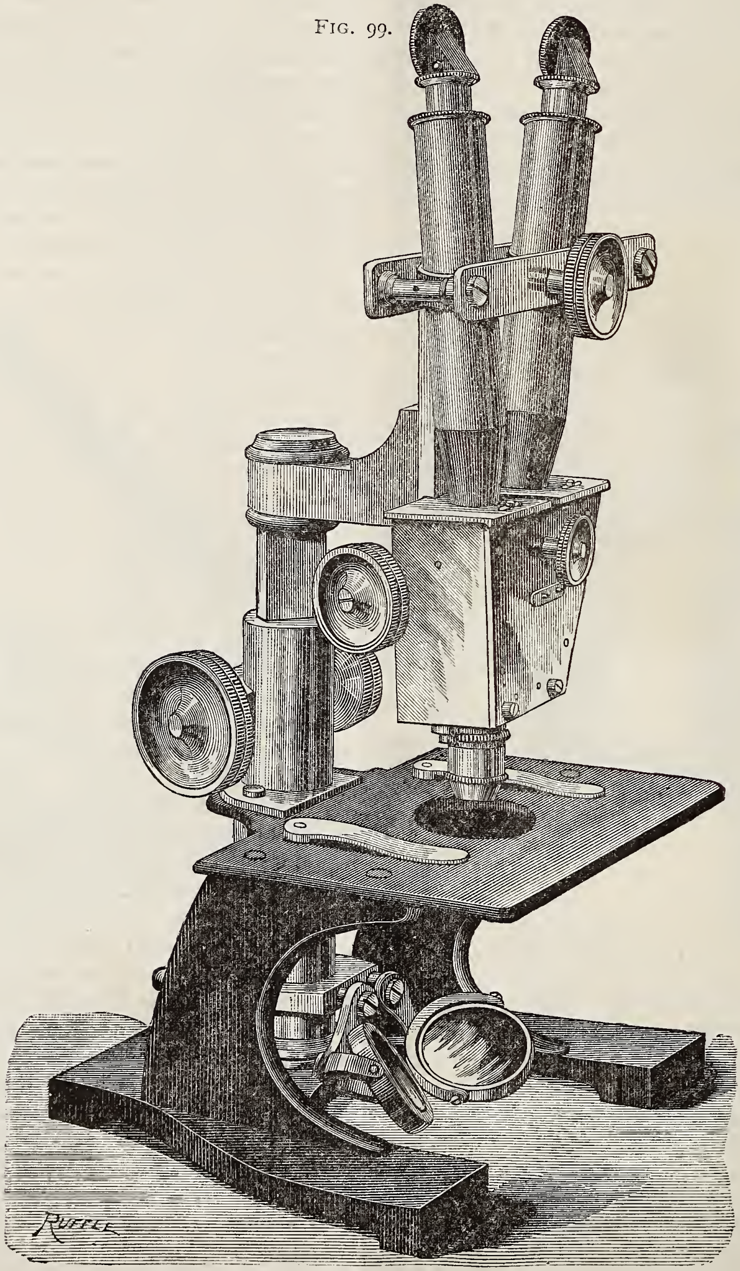
To facilitate the perfect coalescence of the images in the field of view for every width of eyes, Professor Riddell provided (1) a means of regulating the inclination of the prisms by mounting them in hinged frames, so that, while their lower terminal edges remain always in parallel contact, the inclination of the internal reflecting surfaces can be varied by the action of a milled head in front of the prism box; (2) the lower ends of the binocular tubes are connected by travelling sockets, moving on one and the same axis, on which are cut corresponding right and left-handed screws, so that the width of the tubes may correspond with that of the prisms; and (3) the upper ends of the tubes are connected by racks, one acting above and the other below the same pinion, so that right and left-handed movements are communicated by turning the pinion.

Professor Riddell found that, in many cases, it was advantageous to employ two small concave mirrors rather than one large mirror, so as to equalise the illumination in both fields.

To obviate the inconvenience of using the instrument always in the vertical position, small right-angled prisms are so mounted in brass caps as to be slipped at pleasure over the eye-pieces. The combination of the binocular prisms with the eye-piece prisms inverts the image in *both* planes, so that the movement upon the stage is seen through the instrument without inversion.

This system of binocular seems to have excited much curiosity at the date of its first publication in England (1854), and Mr. Wenham, and Messrs. Nachet, of Paris, were soon in the field with a number of binocular arrangements. One of the devices of the latter firm was converted into a binocular erecting eye-piece for the microscope and telescope by Tolles, of Boston, and for moderate magnification I am informed that it is a useful appliance. Mr. Wenham's original contrivance has gone through many modifications, culminating in the system shown in the next Figure.

Fig. 99.

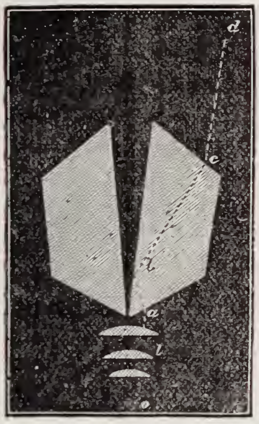


Riddell's Binocular Microscope (1853-4).

Wenham's Binocular Microscope.—The most popular form of binocular microscope was planned by Mr. Wenham about 1862; the action is shown in Fig. 101 (p. 1115).

The prism, P, is so arranged as to take up exactly half the pencil of rays emerging from the objective, O, and after undergoing two total reflexions at the internal faces of the prism, these rays pass across the optic axis in the direction L (the left eye), while the other half of the pencil of rays passes in the direction R (the right eye). This form of binocular appears to have practically superseded all others. The deflection of half the pencil across the axis, so that the right eye receives the left half and the left eye the right half of the original pencil of rays, has been said to be the cause of stereoscopic (true projection) vision; whilst in other binocular systems, where no crossing of the axes takes place and where, consequently, the right eye views, the image formed by the right half of the objective, and the left eye that formed by the left half) pseudoscopic vision is said to obtain.

Fig 100.



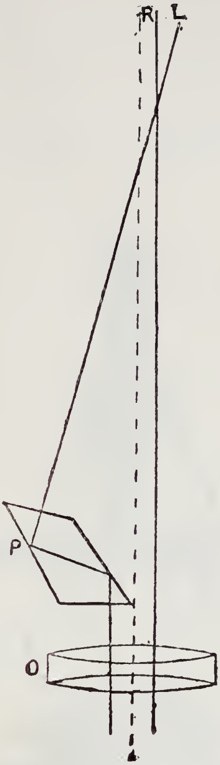
Riddell's Binocular Prisms.

Brücke's Lens.—The revival of the Galilean microscope by Brücke (about 1852) has led to such useful combinations for dissecting purposes, that I cannot omit to notice the instrument.

Brücke proposed to use achromatic doublets in combination with a concave eye-lens, for moderate magnifications, where simple lenses or ordinary doublets or triplets had previously been employed. Fig. 102 shows the form issued by Nachet, in which the eye-lens is mounted in a draw-tube, so that different magnifications can be obtained; the mounting is applicable to any form of simple microscope or lens-carrier. Zeiss has also worked out excellent combinations of this form in fixed settings, and supplies a small stand designed expressly for them. Our opticians appear to have wholly neglected this most useful little dissecting microscope.

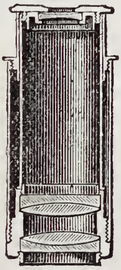
A Japanese Microscope.—This microscope (Fig. 103, p. 1116) was manufactured at Tokio, Japan. The design is evidently copied from a modification of Culpeper and Scarlet's microscope (Fig. 47). The novel points seem to be (1) the arrangement of a groove on the stage in which the object-slide is placed, so that different parts can be viewed by lateral movement—a modification of the rotating multiple stage of Chérubin d'Orléans, to which I have referred; (2) the whole construction is of a vibratory or tremulous character, suggestive of a total misapprehension of the real purposes of a microscope; the body-tube rocks in its socket, and the upper base turns and rocks on the lower one, and if the instrument is touched and released, it quivers throughout, and slowly

Fig. 101.



Wenham's Binocular Microscope.

Fig 102.

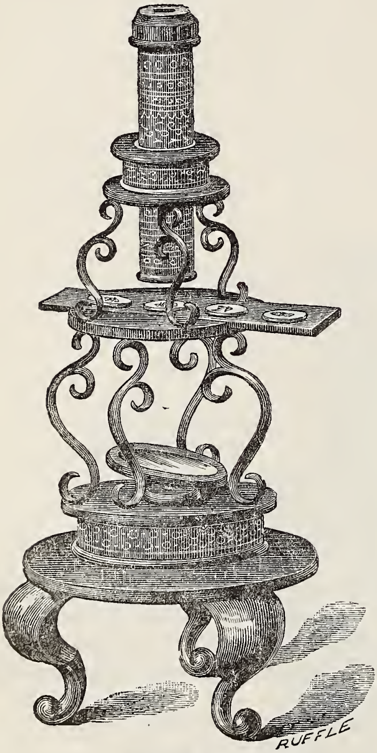


Brucke's Lens (as made by Nachet).

settles down into stillness—provided one does not breathe upon it.

We have now passed in rapid review some of the best types of microscopes designed since the first application of achromatism. The number might be greatly increased, had we time and space, for in addition to the more important type-models I have described, every optician I have mentioned (and many others I have not mentioned) has brought out forms of less and less complete design, to meet the demands of students and others to whom economy of outlay was almost the first consideration. The designs of these less complete instruments are of inferior interest, because we know that the principal criterion by which they are to be estimated is the expense. As a rule, however, those opticians who have devised and made the best class of microscopes, have also devised and made the most serviceable forms of lower class.

Fig. 103.



A Japanese Microscope.

Then, again, numerous designs have been produced for special purposes. We have microscopes for the observation of chemical processes and the fusion of metals, &c., where the instrument has to be protected from the action of acids, gases, heat, &c. Petrological microscopes, where polarising and goniometrical appliances are chiefly embodied (of these I remark, in passing, that M. Nachet has made a specialty, and his instruments are probably the most complete of the kind). Then we have microscopes for recording the growth of plants; for viewing objects at the bottom of an aquarium, by means of an aquatic nose-piece; for observing the circulation of the blood in the frœnum of the tongue, &c.; for counting the threads of silk, wool, linen, &c.; for measuring lengths to an accuracy of 1-100,000 inch or higher; for viewing the walls of the stomach and other internal parts of the body by means of an electric light; for class demonstrations; for field work; for examining large specimens of minerals, &c., for which Marten's Ball-jointed microscope was specially designed, with ball-and-socket movements to the body-tube carriers; and we have several instruments that were designed expressly to compete for the medals offered by the Society of Arts, in 1855, for School Microscopes and Students' Microscopes. The best known models for these and many other purposes are exhibited here, and with due time at my disposal we might pass them all in review.

With reference to accessory apparatus originated or improved in conjunction with the achromatic microscope, I may note that the Huyghenian and Ramsden forms of eye-pieces, as applied to the telescope (or the former slightly modified), have come into use; that Orthoscopic or Aplanatic eye-pieces, and "Holosteric" or solid eye-pieces, have been occasionally applied; partially achromatised (Kellner), and in some cases wholly achromatised (Schrœder) eye-pieces have been tried, but with by no means the amount of advance in optical power that was expected by Lalande, Brewster, and others. Amplifiers have been tried, beginning with Selligue; and latterly they have been achromatised by Tolles and Zeiss specially for photo-micrography.

The greatest improvement amongst the different kinds of apparatus contrived for illumination has been the achromatic condenser as made by Powell and Lealand, which has a series of stops and graduated diaphragms for regulating the light. Other opticians have contrived more or less elaborated forms of sub-stage condenser, in some cases combining a number of appliances in one piece of apparatus; my impression is that, in many of them, too much is attempted, and hence essential points are somewhat neglected. More recently, Powell and Lealand have been working out an achromatic condenser to correspond as nearly as possible with the highest apertures of our objectives; the successful production of this apparatus is waited for with much interest by Dr. Dallinger and others, including myself.

Then we have had many devices for oblique illumination, such as Amici's prism, and Dujardin's prism, variously applied; the "Vertical Illuminator," in which the objective is made to act as a condenser to the object; Reid's "Kettle Drum;" Woodward's Prism; the Hemispherical Lens; Wenham's Semi-disc; the "Diatomoscope;" double-prisms; mirrors arranged to rack close to the base of the slide; silvered glass slips to place beneath the slide to be illuminated from above; prisms cemented on the face of the slide, so as to transmit rays to be totally reflected from the internal surface of the base of the slide; Catoptric and Cata-dioptric Illuminators of almost impossible complexityof action; an Immersion Stage Illuminator; a multiple plane-faced prism and lens; a semi-cylinder Illuminator, and a host of others, the great majority of which have had their day, and are now rapidly being forgotten.

For dark-ground illumination we have had Spot lenses, Amici's Inverted Cone, Shadbolt's Annular and Sphæro-annular Condensers, Wenham's Parabolic Reflecting Mirror, the Wenham-Shadbolt Paraboloid, Wenham's Immersion Paraboloid, Wenham's Reflex Illuminator, and a few other similar contrivances, of which the Spot-lenses and the Wenham-Shadbolt Paraboloid still survive. For "opaque" illumination we have the Lieberkühn, the Selligue Prism, the Parabolic Side Reflector, and a few minor variations of little importance.

Special devices have been contrived to furnish monochromatic light of any primary colour.

Of diaphragms we have had circular, square, oblong, triangular, indeed almost every imaginable shape, tried singly or in series, sometimes combined by means of superposed slides or by rotating plates. In one or two non-achromatic Immersion Illuminators we have had a small circular diaphragm made to move from the axis to the margin of a combination of lenses of high aperture. Rotating calotte diaphragms have been adapted by Zeiss and Swift. We have also iris-diaphragms, combined with condensers or alone, or again used at the nose-piece to reduce apertures. I don't think they have yet been applied to the eye-piece to cut down the field, but this will come, as an "important" modification, doubtless, of other and better methods.

Then we have double, triple, quadruple, and sextuple nose-pieces, first sliding, then rotating, some set at an angle, then curved, then mounted on a calotte, and, for lightness, the best have been made of aluminium. These devices should not be employed on high-class microscopes focussing by the nose-piece, as they are very apt to strain the sensitive mechanism.

Of changing nose-pieces, we have, first, Chevalier's double stud projecting from a ring, slipping into corresponding slots in the face of the socket, and held by a slight rotation; then the Geneva Optical and Physical Company's changing nose-piece, where the objectives have rings with shallow flanges slipping under a spring catch—a method also adopted by M. Nachet, and by M. Bertrand; then we have Mr. Nelson's arrangement, where three short segments of the internal thread of the nose-piece are cut away, and corresponding segments are removed from the screw-threads of the objectives, so that they may be pushed in the nose-piece, and slightly turned, which plan has brought upon us a mass of modifications, suggestive that we should pass the remainder of our natural lives in mastering their construction and use—many of them more troublesome to use than the screw-system they are intended to supersede.

We have more than twenty different arrangements for carrying bull's-eye condensers, as many lamps of special design for use with the microscope, of which Dr. Dallinger's, with its adjustable screens, &c., is designed for the "fine art" of microscopy; while Mr. Nelson's is less complex, but still thoroughly practical.

Then we have screw stage-micrometers, and simple ruled stage-micrometers, and others of various designs, to measure blood corpuscles with or without the aid of photography; screw eye-piece micrometers of both the Huyghenian and Ramsden forms, to be carried preferably on a separate stand, and not in the body-tube, where extreme accuracy is required, as suggested by Mr. Nelson—in some cases, to avoid errors due to unequal magnification of the centre and the margin of the eye-lens, a lateral motion has been added to the eye-lens, so that the measurements are always determined by the image seen in the axis only; Jackson's eye-piece micrometer (a simple and practical device); Hartmack's eye-piece micrometer, with oblique scale; eye-pieces with crossed wires, and with parallel vertical wires for readily estimating comparative dimensions, and others with fine ruled squares of known dimensions, which were generally applied by Andrew Ross and Hugh Powell to the Ramsden eye-piece, at the focus of the combination.

We have Cameræ Lucidæ, such as Wollaston's, dividing the pupil of the eye; Soemmering's steel disc, conveying the image from the microscope to the centre of the pupil, the outer zone of the eye viewing the pencil and paper directly; Beale's neutral tint reflector; many forms devised by Nachet, the best of which has a film of gold on the final reflecting surface through which the microscope image is seen tinged with green colour due to the gold; Zeiss's or Abbe's, which are similar in action to Nachet's; Nobert's, Chevalier's, Beck's, and the best of all that I have tried—Schroeder's, which is a modification of the principle utilised in Wenham's high-power binocular prism.

We have frog plates; animalcule cages or "live" boxes; compressoria; vivisection troughs for showing the circulation of the blood in the lung of the frog; hot stages and reservoirs with multitudinous devices for maintaining an even temperature; stages with electrical appliances for viewing minute vacuum tubes, &c.; safety stages of several designs, the earliest (intended as such) probably by Powell, which is seen on a large microscope he made for Stonyhurst College in 1842, and the simplest form is that recently devised by Prof. Charles Stewart, Curator of the College of Surgeons, in which the slide is held by two india-rubber bands stretched across a light wood frame, useful for class demonstrations. And we have polarisers and analysers of various designs; some of the former give a much larger field than Nicol's prism, and permit the combination with a condenser, as in Hartnack's form; of the latter, some rotate at the nose-piece in the body-tube, or, again, over the eye-piece combination with a graduated goniometrical disc and pointer, as in Hartnack's. Double-image prisms have been devised by Prazmowski and by Abbe. For carrying selenites we have many systems of convenient rotation; and in one instance we have clock-work applied to keep the rotation of one or more plates going, to amuse the ladies when we exhibit sections of the "North Pole," &c., at *soirées.*

Of curiosities among achromatic microscopes, we have here the first Engiscope made for Dr. Goring, an unwieldy instrument, capable of knocking me down if I were to release the ball-and-socket joint without due care. The working microscope of the late Prof. Schwann (of "Cell-theory" fame) of Louvain. The original microscope of Cornelius Varley, for which the Society of Arts awarded him a medal. The original model of the Oberhaeuser Dissecting Microscope, with a telescopic erecting eyepiece applied. The original model of Amici's Horizontal Dioptric Microscope. The working microscope by Amici that formerly belonged to the distinguished Italian, Professor Alessandrini, of Bologna. Wenham's original Binocular Microscope. A copy of Riddell's original Binocular Microscope. Then we have "Jumbo," the largest microscope known; and the "Midget," the smallest working model known; and a prettily-made "drum" microscope, by Alfred Nachet as a lad; and three binocular microscopes, consisting of achromatic objectives sawn through to form binoculars—a sort of quintessence of absurdity for modern binoculars. Then we have some of Tully's early objectives; some of Chevalier's; Amici's, including early oil-immersions, and a ruby-fronted immersion; Wenham's, with his first binocular prism applied almost in contact with the posterior combination; the famous 1-6 inch immersion of Tolles, about which part of the aperture controversy turned; and a 1-4 inch, also by Tolles, with a tiny prism behind the front lens for projecting light upon opaque objects through the front lens.

You will naturally expect me to say something of the progress that has been made in the construction of objectives.

The Selligue objectives I have examined were by no means good, from our present stand-point of excellence; those of Chevalier were unquestionably better; and those of Tully better still. The best I have seen of Tully's were small doublet fronts with larger triplets above. The earliest of Oberhaeuser's were apparently copied from Chevalier's. It is said that Lister's discovery of aplanatic foci led immediately to great improvement in objectives; in proof of this, however, I have only met vague assertive evidence. The English optician who did more than all the others together to improve objectives was the late Hugh Powell, and he repeatedly affirmed to me that every advance he himself had made, since the days of Tully's first efforts, had been arrived at by sheer experiment, without a single hint of any value from any theorist whatsoever. It is also certain that Oberhaeuser, Hartnack, Nachet, senior, knew nothing of Lister's investigations, and yet, as late as 1863, objectives made by them were only slightly inferior to Powell's, and were quite on a par with objectives of any other English maker. Whence I infer that Lister's influence has been much exaggerated.

By sheer experiment it appears to me that the great bulk (if not the whole) of the improvement in England was made down to 1868, when Powell undertook the experiment with the immersion system, in consequence of my showing him certain immersion objectives by Hartnack. In Paris, the frequent visits of Amici from 1824 onwards kept certain of the opticians *au courant* of his incessant experiments, and I have been informed, on reliable authority, that the first immersion lenses he made (about 1840) were designed to be used with certain oils which were regarded as practically equal to glass in refraction, thus really constructing homogeneous-immersion objectives, though without any conception of the possibility of apertures greater than would correspond to the maximum air apertures. Exception was taken by the amateurs of that day to the use of oil, on the ground that their slides were injured by it, and hence Amici gave up the oil-immersion system and adopted water as the immersion fluid. In 1855, he showed a number of water-immersion objectives in Paris, and Nachet, senior, and Hartnack worked out some on the same type. In 1862, Prazmowski joined Hartnack, and the production of immersion objectives made great progress, thanks to Prazmowski's combination of theory and practice, so that, at the Exhibition of 1867, the objectives exhibited by Hartnack were notably in advance of those of his rivals. From 1867, until quite recently, the Paris opticians made but very slow progress with their immersion objectives. In England, on the contrary, no sooner had Powell and Lealand started with the immersion system, than their objectives immediately became the best in the field. Wales, in America, and Spencer turned out high-class immersion objectives as early as 1869-70, and then Tolles engaged upon them with more concentration of effort (for previously he had only made them at intervals), and soon produced "optical curiosities" in which he claimed (1872-3) to have increased the apertures beyond the maximum possible with dry objectives. Meanwhile, Zeiss had been working at immersion objectives, and in his catalogue of 1874 he distinctly claimed apertures of "104° to 108° in a film of water, whereas such an angle of even about 96° would correspond to an angle of 180° in air."

A great controversy took place between Tolles and Wenham on the aperture question, on which I will not enter except so far as to state that, in support of his claims, Tolles published, or caused to be published on his behalf, certain computations relating to the apertures of his immersion objectives. During this controversy, Tolles produced a number of objectives having an extra front lens, which were of special excellence. Amongst them was a certain 1-6 inch that he made for Mr. Frank Crisp, and the aperture of which was the subject of endless published letters, &c.

In 1878 Zeiss produced, under the instructions of Dr. Abbe, oil immersion-objectives, which were afterwards termed "homogeneous" immersion, and was immediately followed in England and America by the best opticians. When Zeiss's oil immersions were first issued, Dr. Abbe stated that the idea of the system had been suggested to him by Mr. J. W. Stephenson, the Treasurer of the Royal Microscopical Society. Of course, I cannot for a moment dispute Dr. Abbe's statement as to the origin of the idea so far as he was concerned; but his testimony related only to the communications as between Mr. Stephenson and himself, leaving wholly untouched the question of Mr. Stephenson's originality. In my opinion the origin of the homogeneous-immersion formula is largely due to Mr. R. B. Tolles, and I think this can be substantiated by the now generally admitted criterion—the priority of publication.

In Vol. X. (1874) of the "Monthly Microscopical Journal," pp. 124-5, Mr. R. Keith published the elements furnished by Mr. Tolles, from which he had computed the aperture of a certain 1-10 inch objective, about which a part of the aperture controversy had turned. Photographs of the computation, *in extenso*, were forwarded to the editor of the journal and to me, for distribution among those interested in the subject; with reference to the copies of the computation sent to the editor of the journal, a note was appended to Mr. Keith's paper stating that they were to be obtained by communicating with the editor.

That computation distinctly traced the rays of light from the posterior focus to the radiant at the front of the objective, and the immersion medium connecting the front lens with the radiant was assumed to be fluid balsam, of the same refractive index as the substance of the front lens, and consequently was homogeneous with it. Clearly this was a published formula for homogeneous-immersion. That the idea of the influence of more highly refractive medium was distinctly in the minds of Mr. Tolles and his friends, was proved incontestably by the statement of Dr. J. J. Woodward, in a paper accompanying that of Mr. Keith, as follows:—

> "Mr. Keith further states that he has computed the spherical aberration of the combination, adjusted as above [*i.e.*, at the position of the correction-adjustment for maximum aperture], and finds it practically *nil*. This being the case, the objective ought to perform well when adjusted to the point of maximum aperture, if *balsam* be used as the immersion fluid in lieu of water. . . . . . Accordingly, in company with Mr. Keith, I tested the objective in this way on *Grammatophora subtilissima* by lamplight,' and we both thought the definition unmistakably better than with water immersion." ("Month. Micr. Journ.," *loc. cit.*, p. 127).

It should be distinctly held in view that the publication of Mr. Tolles's formula took place in 1874, and from that formula any other competent optician might have constructed similar objectives. I think the formula could not be more accurately designated than by the title "homogeneous-immersion formula," though that expression was not employed till some seven years later.

The Zeiss oil-immersion objectives, made to a formula of Dr. Abbe, which he stated was the outcome of a suggestion by Mr. Stephenson, were not issued till 1878, and the formula has not yet been published.

If priority of publication of the formula on which homogeneous-immersion lenses could be produced carries with it the title of inventor, then Mr. R. B. Tolles stands alone as the inventor; but he not only published the formula, he constructed objectives on it. It would not do to say that Mr. Stephenson's suggestion was made with a view to obtaining apertures greater than correspond to the maximum for dry objectives. That might be quite true of Mr. Stephenson in 1878; but it was quite as certainly true of Mr. Tolles in 1874, at a date when Mr. Stephenson denied the possibility of any such apertures.

I have stated the claims of the late R. B. Tolles as against those of Mr. Stephenson under a consciousness of grave responsibility. The future of the microscope will probably be so much involved in the successful development of the homogeneous-immersion formulæ, that the merits of the originators of the system will have more and more substantial recognition. Amici led the way, as I have said, by the application of the immersion system to modern achromatic compound microscopes. He made objectives for use with oil-immersion and then with water-immersion, but, so far as I know, Amici merely aimed at getting more and more perfect correction of the aberrations, without any definite conception of the possible extension of apertures beyond those of dry objectives. The merit of Tolles was that he first published a formula by which the possible attainment of such apertures was demonstrated theoretically, and he supported his case by the practical construction of such objectives. His formula was strictly for *homogeneous-immersion*, and his 1-10 inch objective, by the testimony of Dr. Woodward and Mr. Keith, constructed on that formula, gave its best results when used with homogeneous-immersion. It would be strange, indeed, if, when the history of the evolution of the homogeneous-immersion system comes to be written definitely, the whole credit of its invention should be given to Mr. Stephenson, in the face of the fact, to which I have already adverted, that at the date of the publication of Tolles's formula, Mr. Stephenson denied the validity of that formula by denying the possibility of the existence of the aperture computed, a denial which he appears to have persisted in until about the date of the publication, in English, of Dr. Abbe's admission that such apertures were possible. Mr. Stephenson's conversion from the wrong to the right side of the controversy was, of course, a valuable factor in support of the position of Tolles, whether it coincided accurately with Dr. Abbe's admission of the validity of Tolles's argument or not.

In conclusion, permit me to say that no expressions that I can employ will adequately convey my appreciation of the services rendered by Dr. E. Abbe, of Jena University, by the publication of his researches on the "Theory of Microscopical Vision." Dr. Abbe has revolutionised the old empirical views as to the value of high apertures, demonstrating that high amplifications, unless accompanied by proportionately high apertures, produce necessarily untrue images of minute structure. He has also introduced a practically perfect system of estimating apertures, known as the "Numerical aperture notation," by which not only can an accurate comparison be made of the relative apertures of any series of objectives, whether dry or immersion, but their resolving power under the various conditions of the kind of light employed, their penetrating power, and their illuminating power can now be estimated with mathematical exactness.

Dr. Abbe's services in connection with the practical production of objectives on the homogeneous-immersion system by Mr. Zeiss must also be recognised emphatically. It is known, too, that he has long been engaged on a problem of the highest importance for the progress of all optical instruments—the production of new kinds of glass, by which he anticipates greatly reducing the secondary spectra. Within a few days only we have had news of a most promising character regarding his success. I need hardly say that if this problem reaches a practical solution, microscopy will have a new start.

When I go back in memory to the condition of the microscope in my early days, and pass in review the progress I have witnessed in the construction of the instrument both optically and mechanically, in view of the great strides made in my time and of the possible improvement foreshadowed by Dr. Abbe's latest researches in the combinations of new kinds of glass, I am led most strongly to the conclusion that microscopy has before it the prospect of a glorious future.

For the use of the wood-cuts Figs. 79-83, 86, 92, 93, 97-100, 102, and 103, my acknowledgements are due to the Royal Microscopical Society.

ELEMENTARY LECTURES.

ELECTRICITY.

By Professor George Forbes.

Lecture VI.—Delivered May 22nd, 1886.

Practical Applications of Electricity.

At the conclusion of my last lecture I stated that I proposed to make an alteration in the programme. I had originally intended that my last lecture should have been upon the subject of electrical measurement, showing how a system of electrical units has been evolved, each one dependent upon the other. This would have been a very interesting field, and is a most important matter, and I should have been glad to include it in the course of lectures; but the course was started with a special object in view, that of passing in review all the fundamental principles and laws of electricity which regulate these numerous applications which we meet with every day, and to enable those who are not practical electricians to be able to understand what they meet with in the course of their daily life, in the numerous applications of electricity. For this reason I announced last week that I intended to change the subject of this lecture, and to review in a sketchy manner some of the more important practical applications of those general laws, principles, and discoveries which we have been examining for the last five lectures, and to show how these things are applied in actual practice. To-day I shall deal with some of the more important applications.

Among these applications I think you will all agree with me that the most important at the present time is the great facility which we have acquired of creating almost unlimited quantities of electricity by means of the transformation from mechanical power into electricity. This is the result of the dynamo machine. After that I propose to say something about another application, which has had a great deal to do with the development of civilisation in its present form, and that is the invention of the electric telegraph. And, in conclusion, I propose to speak of the still later invention, but one which has attained such a vast application in the short period of its existence, namely, the telephone.

In the development of invention applied to the progress of civilisation, there are two essentially different parts to be carried out. First, there is the grand field of discovery, and in this field of discovery in electrical science no name stands higher than that of our celebrated countryman, Faraday, whose name has been so often mentioned in these lectures. And, secondly, there is the work of the practical inventor, who realises the tools which have been put into his hand by the philosopher, and who applies these tools to evolve practical ideas, and turn out inventions which assist the progress of civilisation. I am first going to speak to you about the manner of construction of the dynamo machine, and all that I can hope, in this sketchy review of the subject, is to be able to tell you enough about it so that, when you see a dynamo machine running, you may be able to appreciate the object and purpose of the several parts of that machine, and be able to judge to some extent how far these different parts seem to be suitable to fulfil their offices.

In my last lecture, I showed you the action of this little machine which is due to Faraday, consisting of a coil of wire which is capable of rotation round one of its diameters. In doing so, it cuts the earth's lines of force—that is to say, it cuts the direction in which the earth's magnetic force is acting, and whilst it is cutting that direction it is creating a current of electricity in the coil of wire. This is the fundamental notion in the construction of nearly all dynamo machines such as we have at present. Moreover, in this little instrument, it was necessary to introduce what is called a commutator, to reverse the current at each half revolution of the coil, because, as the coil takes successive half turns, the direction of the current in the coil is reversed; and, therefore, we must have a commutator to reverse the current going to the external circuit, in order to keep the current continuously in the same direction in the external circuit. By the arrangement of this revolving coil and the commutator, I was able to show you, by means of the galvanometer, the production of a continuous current. The main principle of the dynamo machine is contained in this apparatus. The modifications which we find in special machines are merely modifications to increase the power which we derive from the action which is exhibited by this little instrument. If I were to introduce a ball of iron into the centre of the coil which is rotating, the earth's magnetism would induce a considerable amount of magnetism in that iron while the thing was rotating; much greater intensity of magnetisation, therefore, would exist in the space which is cut by the coil in the course of its rotation than actually takes place when there is no iron. That, you will find, is one of the steps which has been taken in the evolution of the dynamo from this simple apparatus.

Then, again, the earth's magnetism is comparatively feeble, and we are able, by means of electro-magnets, to produce far more powerful fields of magnetisation than that which is produced by the earth. The second step in the evolution of the dynamo is to produce a more powerful field than the earth's magnetism, in fact, to produce as powerful a field as we can possibly succeed in doing. That is done by causing the rotating part to rotate between the poles of a powerful electro-magnet. The principal variations which we find in the construction of dynamos depend, to a large extent, upon the proportioning of these electro-magnets so as to produce the most intense field possible for the revolving part to rotate through. The revolving part is usually called the armature. The iron part, with these coils round it, which produces the field of magnetism—that part is usually called the field magnets.

I will now show you upon the screen, in succession, a few slides illustrating the progress of the dynamo machine.

[Various diagrams were here thrown on the screen and explained.]

I have on my table to-day a question, "Will Professor Forbes kindly explain the movement of the Ferranti meter: why it goes the same way round, whichever way the current passes?" I am very glad to answer any question any of my audience wish to ask me, and I may answer this question, not in connection with the Ferranti meter, but in connection with these dynamo machines when I am using them as motors. If I send a current round in one direction, I make, we will say, the upper pole the north pole, and the lower pole the south pole; and the current in the armature is going in a certain direction, and therefore the armature goes round. Now, if I reverse the direction of the current, what happens? I reverse the polarity of the machine, and have the south pole at the top instead of the north pole, and therefore the armature would tend to go round in the opposite direction. I have also the current going round in the opposite direction in the armature. Thus, as two negatives make an affirmative, I have reversed the polarity of the machine, and have reversed the direction of the current influenced by the poles, and, therefore, the movement is exactly the same, whether I send the current round in one direction or in the other.

As to the applications of these powerful currents which we are able to develop by means of the dynamo, I need say but very little. We have brilliant evidence before us just now, in these glow lamps which are lighting up this room, of the power they have in illuminating by that means. I will throw on the screen an image of the arc light and of the carbon points which are used in its production, and which I have been using in the lantern, and I will just draw your attention to one point, and that is the creation of a crater in the positive pole. Particles of carbon are continually flowing from the positive pole to the negative one; they are leaving the positive pole, making a crater, and piling themselves up on the negative pole, and creating a little mound. At the same time, however, both poles wear away, owing to several different causes, but the positive pole, perhaps, in consequence of that action, wears away more rapidly than the negative pole does. That crater is the most intense source of light.

I will now draw attention to some other appliances which are very useful in the application of electricity, such as secondary batteries—or accumulators, as they have been called—which are a very perfect form of battery, as by sending a current in the opposite direction to that in which they naturally create one, we are able to recover the elements of the substances in the battery, and to reconstitute them, and to renew the battery simply by passing a current of electricity through them; so that, by means of a dynamo machine, we are able to renew our battery as often as we please. I may also draw attention to a very brilliant application of induced currents, shown by this apparatus, called a secondary generator, or transformer. There is a long iron core, with two coils of wire wound round it; an alternating current of electricity is sent through one of the coils, and the secondary coil is connected with the lamps.

By this means we can convert a high tension current into a low tension current, and *vice versa*. The apparatus is one which is likely to have a most important future in the application of electricity to lighting towns, especially when we have to carry the electric current a long distance. There is great economy in the use of high tension currents, but in houses we must have a low potential; we must have currents of no very great electromotive force, and this apparatus will help us in the distribution of electricity very largely in the future.

I must now leave this subject, and come to the second application which has affected the progress of the world so much—the application of electricity to telegraphy. Through the kindness of Mr. Preece, I have on the table some specimens of the different kinds of telegraphs which are used. Here is one of the oldest forms used in England, the needle instrument. You have seen how a current going through a coil of wire deflects a compass needle. Advantage was taken of that to make this needle indicate the different letters; thus, a motion of the needle to the left first and then to the right would mean the letter A, and by combining the motions to left and right, we can make all the different letters of the alphabet. Here is a sounder which was founded on the principle of the electro-magnet. There is an electro-magnet here, with an iron keeper in the top of it. When a current of electricity is passing, the keeper moves, and makes a noise. Mr. Probert will give us the alphabet upon it, in short and long sounds. The short ones represent the motion to the left of the needle instrument, and the long ones the motion to the right. Thus, these wires may be at any distance—one instrument may be in London, and the other in Manchester—and we are able to convert it into an electro-magnet by means of the wire, and so receive the sounds. Here, again, is a Morse inker, in which an electro-magnet works on a keeper, and attracts an inking roller, and so it makes marks on a strip of paper which is drawn out by means of clockwork, which marks are long and short, and so by combination, as before, we can make all the letters. Thus the operator in London is able to converse with the operator in Manchester, by producing these marks in a permanent form on a strip of paper.

I have here a very beautiful apparatus devised by Sir Charles Wheatstone, one which is used very largely in this country, and which is, I believe, used almost only in this country. It is the most rapid system of telegraphy which we possess. It is so rapid that it is impossible to send messages by the hand quick enough, and the message has to be prepared by punching holes in a strip of paper,—the holes are punched at the two edges of the strip of paper, and so dots and dashes are transmitted. Mr. Probert is now preparing the alphabet, and you would think that was quick enough for any ordinary purpose, but the speed at which a skilful operator can punch is nothing compared with the speed at which the actual apparatus works. This punched paper is then driven at great speed through clock work, and another piece of clockwork drives another piece of apparatus similar to the Morse inker. Whenever a hole passes over a certain spot, contact is made, an electric current is sent through to the other instrument, and a mark made on the strip of paper, long or short, according to the way in which it is punched. This apparatus is continually working just now over long distances between England and Scotland, at the rate of 400 words a minute, and it frequently works up to 450 words a minute. The great advantage of this apparatus is, that when you have a Queen's speech, for instance punched out on one of these strips of paper, you can send it through this instrument first to Edinburgh, and then to Liverpool or Manchester, and every other town in succession, and the same punched paper will send it through to each one of them in a very short space of time indeed.

Now, I come to the telephone. But I must confine myself to the Bell telephone, in which the same instrument is used to transmit speech and also to receive it. The Bell telephone consists essentially of a magnet contained in a long cylindrical holder, with a soft iron termination, surrounded by a coil of wire. In front of this soft iron pole piece there is placed a disc of thin iron. When I speak against this disc of thin iron I cause it to vibrate in accordance with the vibrations of the sound. Every time it approaches the iron it disarranges the magnetic condition in the neighbourhood of the coils of wire, and we know that when that happens, a current of electricity is always set up in the coil of wire. Thus, every time the disc vibrates in accordance with my voice, a current of electricity is sent through the coil of wire to the distant station, where the other person is listening. Now, see what happens at the other station. The listener uses an exactly similar apparatus, and the wires which come to his room are connected with the coil of wire in his apparatus. A disc of iron is placed in front of a pole piece in the same way, and every time that a current of electricity passes it attracts this disc of iron. Thus, if we have a thousand vibrations in a second reaching us, this disc vibrates a thousand times in a second, and in proportion to the number of vibrations the speaker is creating in the air and against the disc which he is using, so is the number of vibrations which is listened to by the receiver. Consequently, the sounds heard by the man who is receiving the message are identical with those which are being spoken by the sender. I have no time to go more fully into the description of the apparatus; I simply say that this is one of the most marvellous applications of electricity which has been known. It could hardly have been conceived possible that these minute motions which every substance does undergo when in the neighbourhood of a sound—that these minute vibrations would be sufficient to create currents of electricity which would go away to a distance, and perform so useful a purpose. It is a perfect marvel in the way of the practical application of electricity to everyday life.

I will try to show you the principle of this by means of an apparatus I have here. This apparatus will take the part of the transmitter. I have a magnet and a coil of wire. Round its extremity I have another lump of iron, which I can cause to approach or recede from the face of the coil of wire. At the other end of the table I have an electro-magnet with two poles vertical, one above the other, and in front of it I have a piece of iron suspended by a thread from above. If then, I move the piece of iron at one end backwards and forwards, it will create currents of electricity in the coil, which will go to the electro-magnet which has the iron swinging in front of it. There is an image of the iron thrown on the screen, and, I dare say, by properly timing it, I shall be able to make the vibrations visible; you see the extent of the vibrations increases. This shows that the currents created here are synchronous with those created there, and that we are able, by the motion of a piece of iron placed in front of a coil containing a magnet, to influence another electro-magnet, and so to influence a piece of iron which is suspended in front of it.

Speaking of these applications where sound is, as it were, converted into electricity and reconverted again into sound, it may seem incredible to you that the sound waves are real existences, and that these vibrations which are produced on the vibrating disc are really simply the sounds which are being uttered. No more convincing proof of the truth of this fact could be shown than that which was given by Mr. Edison in the invention of the phonograph. I will show you the action of that presently; but before doing so, I will show you the action of a telephone from a distance. Mr, Vesey, who just left the room, will play a violin downstairs, which is connected telephonically with this telephone I hold in my hand. When I put a cone of paper in front of it, you will be able to hear the tones coming from the violin, only in a somewhat altered form.

In conclusion, I will illustrate this fact of the reproduction of sound by Mr. Edison's phonograph. In this apparatus we speak towards a disc, which moves a point of metal backwards and forwards, in accordance with the vibrations produced by the voice. That point presses upon a piece of lead foil, which is wrapped round a cylinder which is rotated; the cylinder having a screw on the axle, so that every part of the cylinder comes in turn under the point. When I speak into the apparatus, the point makes marks on the lead-foil of a character corresponding to the sounds I am making, and when I have finished speaking, there is an impression on the lead-foil, which is a record of what I have been saying. On winding the apparatus again in the same manner round its axis, the lead-foil will strike against the point, and wherever there is a depression, the point will be free to move forwards a little; wherever there is no depression, the point will be forced back again. Thus, in accordance with the indentations which my voice has caused to be made on the lead foil, so will the lead foil, in its turn, cause the point to rise and come forward, and to recede, and it will act in the same way on the disc, and thus we shall have the disc being caused by the lead foil to move backwards and forwards in an exactly similar succession of movements as it executed when I was speaking to it in the first place. Thus the sounds of the voice which were originally put into it will be reproduced by turning the handle, under the influence of the record which was put upon the lead-foil. This is not an electrical experiment in any way; but still it serves to illustrate the applications of electricity.

Miscellaneous.

COLONIAL AND INDIAN EXHIBITION.

CONFERENCES.

The Conferences under the direction of the Conference Committee will recommence next week, when Papers will be read, on Wednesday, October 6th, on "The Pearl Fisheries of Ceylon," by G. Vane, C.M.G.; and on Friday, October 8th, on 'Canada as a Flax-Growing and Linen-Manufacturing Region," by E. B. Biggar. Papers will also be read, on dates to be hereafter announced, on "Stock Raising in Canada," by Professor Smith; on "The Climate of Canada," by W. Hingston; on "The Canadian North-West," by Captain Clarke; on "The Cocoa-Nut Palm of Ceylon: its Products and other Uses," by J. Capper; on "Ceylon Tea," by J. L. Shand; on "St. Helena: its Past, Present, and Future," by Col. Palmer; on "British North Borneo and its Resources," by W. B. Pryor; on "The Social Conditions of Cape Colony," by Spencer Todd, C.M.G. It is also probable that a second Conference will be held by the National Fish Culture Association.

THE PROIOSED COLONIAL AND INDIAN INSTITUTE.

A preliminary meeting of bankers and merchants of the City of London was held on Monday, 27th ult., at the Mansion-house, on the invitation of the Lord Mayor, to consider the letter of the Prince of Wales inviting co-operation in the formation of an Imperial Institute of the Colonies and India as the memorial of her Majesty's jubilee by her subjects. The Lord Mayor presided.

The LORD MAYOR, in opening the proceedings, thanked those present for their attendance at somewhat short notice, and said they were met to consider the letter of the Prince of Wales on the subject of the commemoration in some special manner of the approaching jubilee of her Majesty's reign, and of the formation of an Imperial Institute of the Colonies and India as such memorial. He thought that the citizens of London would be highly complimented by being placed in the forefront of a movement which was not confined to the City or to the kingdom, but would embrace the whole of the English-speaking communities wherever they might be found. Having read the Prince's letter and his own reply, the Lord Mayor went on to say that he thought they might take for granted that there was a general desire and a general anxiety that the coming jubilee of her Majesty's reign should be commemorated in some special and adequate manner. The suggestion which the Prince of Wales had made for the form of that commemoration was that it should be an institute representing the arts, manufactures, and commerce of the Queen's colonial and Indian Empire, "stimulating emigration to those British territories where it was required, expanding the trade between the two different communities, and drawing closer the bonds which united the Empire—an institute which would be at once a museum, an exhibition, and the proper locality for the discussion of Indian and colonial subjects." The more important collections in the present Exhibition would probably be placed at the disposal of the institute, and the contributions towards it would be vested in a body of trustees whom the Sovereign would be asked to nominate, the institute being under the permanent presidency of the Heir Apparent to the Throne. It would thus be seen that the movement had no political or party character; it would take the form considered to be the most useful and the most acceptable; it would be joined in by all classes and creeds, and from it great benefits to the country might be derived. There would naturally be very many details to be hereafter settled, which, he thought, would depend a great deal on the amount collected; but he ventured to believe that the Prince of Wales's suggestion would be considered a singularly appropriate one for commemorating the Royal jubilee, and would be supported by all classes of her Majesty's subjects. He had called that meeting as a preliminary step to launching the Mansion-house fund before the public

The GOVERNOR of the BANK OF ENGLAND said he had to express the most cordial sympathy with all that had fallen from the Lord Mayor. The desire to show their love and affection for the Queen was universal throughout the Empire, and the citizens of London would be foremost in doing their share towards celebrating the jubilee in the way suggested. In order to give practical effect to the meeting, he moved that a small consultative committee, to be selected by the Lord Mayor, be appointed to consider the best steps to be taken to raise the fund.

Mr. Alderman and Sheriff Evans seconded, and Mr. J. S. Morgan supported the resolution, which was put and carried by acclamation.

The office for the receipt of donations is at the Mansion-house, and the account of the fund is at the Bank of England, where amounts may also be paid.

The sub-committee for the testimonial to the Prince of Wales have had laid before them the following letter from his Royal Highness the Prince of Wales addressed to the Chairman:—

"Abergeldie Castle, Sept. 19, 1886.

"My dear Cadogan,—As I understand that you are the chairman of the committee which has been formed for the purpose of collecting funds for a testimonial to be presented to me as Executive President of the Colonial and Indian Exhibition, I wish to write and express to you and the other gentlemen who have so kindly moved in this matter how deeply I appreciate the compliment they propose to pay me.

"I feel, however, that I cannot accept any personal present, though I am most sensible of the kind feeling which has prompted it; but as you are aware that it is suggested, in commemoration of her Majesty's jubilee year, to establish an 'Imperial Institution' for the colonies and India, in the promotion of which I take the deepest interest, I should be most grateful if the subscribers would allow the funds collected for my testimonial to be applied in aid of that object.

"Should they kindly do so, it will be an ample reward to me for any services I may have rendered to make the Exhibition of 1886 a success.

"Believe me, my dear Cadogan, very sincerely yours, "Albert Edward P.

"The Earl Cadogan, &c."

The following resolution was proposed and unanimously adopted:—

"That, in view of the letter addressed by his Royal Highness, the Executive President, to the chairman of this committee, in which his Royal Highness, while conveying his grateful appreciation of the proposed testimonial to himself, expresses the wish that it may not take such a form, but that any funds collected may be applied towards the 'Imperial Institution,' which it is intended to found to commemorate the jubilee year of her Majesty's reign:

"Resolved therefore,—'That the committee, believing it to be the wish of the subscribers to evince their high sense of his Royal Highness's great services in the manner most acceptable to himself, acquiesce in the suggestion contained in his letter.

"'They desire, at the same time, to record what they are assured will be the unanimous feeling of all the donors, that the step thus taken by his Royal Highness will, if possible, add to the appreciation entertained of his disinterested and public-spirited efforts, not only on behalf of an Exhibition from which many millions of her Majesty's subjects have already derived so much advantage, but to further a project which will at once be a graceful memorial of her Majesty's long and happy reign, and conduce to the permanent consolidation of the Empire.'

"It was further resolved,—'That the chairman report the foregoing proceedings for the approval of the full committee and the subscribers.'"

General Notes.

Production of Chestnuts in Italy.—According to the latest returns, published by the Minister of Agriculture, it appears that the chestnut tree is cultivated in every province of Italy, excepting those of Milan, Cremona, Mantua, Rovigo, Ferrara, Ancona, Bari, Lecce, Syracuse, Girgenti, and Trapani, that is to say it is culvated in 56 provinces, and that out of the 8,257 communes in Italy, it is cultivated in 1·3137. The chestnut is cultivated on the most extensive scale in Liguria, and on the least in Sardinia. The total production throughout the kingdom of fresh chestnuts is 391,393 tons annually, which would average $1\frac{1}{3}$ kilog. per inhabitant, in Liguria it reaches $101\frac{1}{2}$ kilos. per head, and in Sicily only 3·57. A considerable quantity of chestnuts are exported to France, Austria, Egypt, Switzerland, and South America, whilst, on the other hand, a very insignificant quantity are imported from France, Austria, and Switzerland.

Newcastle Exhibition.—Arrangements are being made at Newcastle-upon-Tyne for holding there a Mining, Engineering, and Industrial Exhibition (International and Colonial) in 1887, "in order to mark in the annals of Newcastle-upon-Tyne, the Jubilee year of the reign of Her Gracious Majesty." The prospectus states that "the Industries, Manufactures, and Products of the neighbourhood alone are sufficient in number and interest to occupy a very important part in the exhibits. Mining, which is its chief industry, will be specially represented, and it has been arranged that a complete full-sized working model of a mine shall form a special feature of the Exhibition. Amongst other important industries and manufactures of the district are shipbuilding, ordnance, marine, and other engine works, chemical manufactures, iron and steel works, and many others." The Exhibition will open on the 24th May, and large exhibits must be delivered not later than 31st March, smaller exhibits being received up to the 14th April. The promoters of the Exhibition are anxious to make the Exhibition as representative as possible, and to bring it under the notice of foreign exhibitors.

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All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

Proceedings of the Society.

THE TREATMENT OF SEWAGE.

By Dr. C. Meymott Tidy.

[The following is the full text of Dr. Tidy's paper, an abstract of which was delivered before the Society of Arts, on April 14th last, and published in the *Journal*, No. 1743, April 16, 1886.]

Liquid Excreta.

Every adult male person voids on an average 60 ozs. (= three pints) of urine daily. The 60 ozs. contains an average of 2·53 oz. of dry solid matter, consisting of—

Urea......................	512·4 grains.
Extractives (pigment, mucus, uric acid)................	169·5 ,,
Salts (chiefly chlorides of sodium and potassium)....	425·0 ,,
	1106·9 ,,
	= 2·53 ozs.

The urine, therefore, of a population of 10,000 adults may be taken as 600,000 fluid ozs., or 3.750 gallons per day.

Urine rapidly decomposes, the urea becoming the volatile body carbonate of ammonia, and the urine thereby losing a valuable manurial constituent. After a time, but at a later stage, certain foul smelling gaseous products of decomposition are evolved. To collect and preserve urine, therefore, presents practical difficulties. The ammonia from stale urine was formerly distilled and converted into a sulphate, at Courbeville, near Paris.

Solid Excreta.

Every adult male person voids about 1,750 grains (or 4 ozs.) of fæces daily, of which 75 per cent. is moisture. The dry fæcal matter passed daily is therefore about 1 oz. per adult head of the population. Of this *dry* fæcal matter, about 88 per cent. is organic matter (of which 6 parts are nitrogen) and 12 per cent. inorganic, of which 4 parts are phosphoric acid. Of this dry fæcal matter 11 per cent. is soluble in water.

Taking a population of 10,000 adults, it follows that the moist fæcal matter passed daily is equal to 2,500 lbs. (= 1 ton, 2 cwt., 8 lbs.) or 1·116 ton, whilst the dry fæcal matter is equal to 625 lbs. (5 cwt., 2 qrs., 9 lbs.).

The facts, therefore, respecting the excreta of a population of 10,000 adults may be thus tabulated:—

Table I.—Fæcal Matter passed per 10,000 of Adult Population per diem.

	lbs.
Moist fæcal matter excreted...........	2,500
Dry ,, ,, ,, (calculating 75 per cent. as moisture)	625
Soluble in water = 68·55 lbs. .. Insoluble in water = 556·45 lbs.	= 625

Table II.—Urine and Fæces passed per Day by 10,000 Adults.

	Total solids.	Water.	Solids dry.	Solids soluble.	Solids insoluble.
	Moist lbs.	Gallons.	lbs.	lbs.	lbs.
Fæces ...	2500	187·5	625·0	68·55	556·45
Urine ...	—	3750·0	1581·21	1581·21	—
		3937·5	2206·21	1649·76	556·45

The Table on p. 1128 has been adapted from Letheby. The quantities given are somewhat below the normal. The facts were collected from a number of sources, the ratio of children to adults being that adopted by Röderer and Eichhorn.

My own experiments would lead me to give one pint as an average quantity of urine passed by children daily up to the age of ten years, the quantity gradually increasing up to three pints in the adult. The solid constituents of the urine which, at the age of ten, are on an average 0·8 oz. daily, increase, according to my observation, up to 2·5 ozs. in the adult. The quantity passed by girls and women is rather less than that passed by boys and men.

The fæces passed by girls and women are

CONSTITUENTS.	Weight in ounces avoirdupois of chief constituents of urine and fæces passed by children and adults in 24 hours.					Weight in lbs. of urine and fæces contributed by a mixed population of 10,000 persons (1,644 boys, 3,020 men, 1,662 girls, 3,674 women) in 24 hours.				
	Males.		Females.		Average at all ages.	Males.		Females.		Total at all ages.
	Boys.	Men.	Girls.	Women.		Boys.	Men.	Girls.	Women.	
URINE.	oz.	oz.	oz.	oz.	oz.	lbs.	lbs.	lbs.	lbs.	lbs.
Fresh urine	19·875	48·490	16·881	42·157	31·851	2073·2	9152·5	1753·6	9680·3	22659·6
Dry constituents	0·969	2·197	0·750	1·588	1·376	99·6	414·7	77·9	364·6	956·8
(*a.*) *Organic matter*	0·677	1 720	0·574	1·216	1·072	69·5	324·6	59·6	279·2	732·9
Containing nitrogen	0·166	0·481	0·161	0·326	0·284	17·1	90·8	16·7	74·9	199·5
(*b.*) *Mineral matter*	0·292	0·477	0·176	0.372	0·332	30·0	90·0	18·3	85·3	223·9
Containing phosphoric acid	0·035	0·069	0·024	0·049	0·044	3·6	13·0	2·5	10·6	29·7
,, potash	0·040	0·078	0·027	0·055	0·050	4·1	14·7	2·8	12·7	34·3
FÆCES.										
Fresh fæces	3·421	5·240	1·061	1·414	2 784	351·5	989·9	110·2	324·7	1775·5
Dry constituents	0·879	1·112	0·282	0·376	0·662	90·3	209·9	29·3	86·3	415·8
(*a.*) *Organic matter*	0·762	0·939	0·244	0·325	0·567	78·3	177·2	25·3	74·6	355·4
Containing nitrogen	0·049	0·062	0·016	0·022	0·037	5·0	11·7	1·6	5·0	23·2
(*b.*) *Mineral matter*	0·117	0·173	0·038	0·051	0·095	12·0	32·6	3·9	11 7	60·2
Containing phosphoric acid	0 039	0·062	0·013	0·018	0·033	4·0	11·7	1·3	4·1	21·1
,, potash	0·014	0·023	0·004	0·006	0·012	1·4	4·3	0·4	1·4	7·5

considerably less than that passed by boys and men. The calculations in the Table state the amount as less than one-third. My own observations, however, scarcely support these numbers. It would, I think, be more accurate to regard the fæcal matters passed by female children and adults as about one-half that passed by male children and adults.

VALUE OF NIGHT SOIL (HUMAN EXCRETA).

Urine, in its natural condition, has a theoretical value of between 15s. and 16s. per ton. The dry solid matters of the urine have a theoretical value of about £18 16s. per ton.

The quantity of ammonia per year voided by the average individual in the urine has been stated as from 10 lbs. to 11·32 lbs., having a value on the lower quantity of 6s. 8d., and on the higher of 7s. 3d.

Fæcal matter, in its moist and natural condition, has a theoretical value of £1 7s. 6d. per ton. The dry solid matters of fæces have a theoretical value of £5 17s. 7d. per ton.

The quantity of ammonia voided per year in the fæces, by an average individual, is estimated at 1·64 lbs., having a value of about 1s. 3d.

The estimates given above are based on the agricultural values of the nitrogen calculated as ammonia, together with the phosphoric acid and potassium salts, these being materials of sparing occurrence in land, but entering largely into the composition of every variety of agricultural produce. Lime, magnesia, and iron, equally essential to plant development, occur largely in most soils. The details are stated in the Table on p. 1129:—

Respecting the value of the nitrogen, however, of sewage, Voelcker regards it as at least of 10 per cent. less value than the nitrogen of ammoniacal salts ready formed.

Authorities differ between 6s. 6d. and £1 in estimating the annual value of the excreta of one adult. Thudichum gives it at £1; Hofmann and Witt at 11s. 9¼d.; Voelcker at 9s.; Lawes and Way at 8s. 5¾d.; Anderson, of Glasgow, at 8s.

In the Table we have estimated the mixed excreta of the population as worth 15s. 8d. per ton in their natural condition, and the solid matter of such mixed excreta as worth £14 16s. 4d. per ton.

In this Table, moreover, no corrections are made in stating the value of the solid constituents, either for the loss of ammonia that would occur during evaporation, or for the soluble phosphoric acid of the fresh excreta becoming insoluble by its combination with lime, after drying. No doubt the loss from these causes is considerable, and tend to show that, when used as a manurial agent, sewage should be applied to the land in its fresh state.

These estimations of value are theoretical only. Cesspool matter in Paris fetches from

Composition and Estimated Value of the Solids of Urine and Fæces, and of the Mixed Excreta of a Population.

Constituents per ton.	Ammonia (= 7d. per lb.)	Phosphoric acid.		Potash* (= 3d. per lb.	Estimated value per ton.
		Soluble (= 4d. per lb	Insoluble* (= 2d. per lb.		
A. Natural State.	lbs.	lbs.	lbs.	lbs.	£ s. d.
a. Urine	23·94	2 94	—	3·39	0 15 10
b. Fæces	35·45	—	26·62	9·46	1 7 6
c. Mixed excreta of population	23·13	2·70	1·93	3·83	0 15 8
B. Solid Matters of.					
a. Urine	567·14	69·53	—	80·32	18 14 1
b. Fæces	151·77	—	113·67	40·40	5 17 7
c. Mixed excreta of population	441·31	48·47	34·43	68·21	14 16 4
d. Sewage of mixed population	172·10	22·89	10·19	48·20	6 3 2
Rotten farm-yard dung	16·0	3·92	5·77	10·00	0 14 1
Fresh farm-yard dung	15·0	3·0	3·92	12·50	0 13 6
Peruvian guano	381·8	67·0	201·00	13·50	14 1 4
1,000 tons of average London sewage	219·37	27·61	24·20	50·65	0 0 1¾

* 2d. per lb. would perhaps be nearly the value of potash, and 1d. the value of phosphate of lime.

1 franc to 1 franc 25 cents per cube metre (about 1 ton), whilst in Holland and Belgium the average is one shilling per head per annum for the excreta. It would scarcely be an exaggeration to place the real value of the excreta at about one-sixth their calculated value.

Certain comparisons, in respect of fertilising power (and, therefore, of agricultural value), are worth noting—

1 lb. of human excrement.... = 13 lbs. of horse dung.
" " " = 6 lbs. of cow dung (Macaire and Marcet).
Excreta of one adult (solid and liquid) .... = Droppings from one sheep (Mechi).
Yearly excreta (solid and liquid) of one adult.............. = 75 lbs. of Peruvian Guano (Voelcker). (This will yield 3·2 bushels of grain).
" " " " = Yield of sufficient nitrogen (16·41 lbs.) to furnish the nitrogen of 800 lbs. of wheat, rye, or oats; or 900 lbs. of barley, value £5. (Boussingault.)

Middens.

Sewage absorbents.—The cesspool and the midden were the first attempts at collecting excreta, not so much, however, for the purpose of profit as with the idea of preventing nuisance. The cesspool had many and great disadvantages, not the least of which were the noxious inhalations evolved, the necessity for occasional emptying, and the pollution of the drinking water of the wells in the neighbourhood. The ash-pit midden had, and has, its advantages and its difficulties. Of the difficulties, the education of the people to use them properly was chief, a difficulty, however, that applies almost as much to water-closets as to middens. A second difficulty in the use of the middens consisted in securing proper scavengering arrangements by the local authority, a difficulty, it may be again noted, not one iota less great in securing the efficient treatment of sewage. Provided the midden be regularly attended to and properly constructed, *e.g.*, erected away from the house—the pit small—roofed in so as effectually to stop out rain or other water—floored with sloping flags to render the removal of the contents easy—impervious to surface water and not drained, dryness of contents being effected by the use of ashes well distributed over the soil—there are more objectionable ways of dealing with refuse than by the midden system. Under conditions of individual and general supervision, the compost, if sufficiently often removed, need not be a nuisance. But if the midden be neglected by the public authority and by the householder, no doubt it may become a prolific source of disease, as Manchester and Liverpool can testify.

The advantages of the pail system are not to be overlooked. Thus the pails are always placed outside the house; whilst a certain regular process of inspection is rendered necessary, ensuring the detection of a nuisance before it becomes a source of danger. In time of epidemics, again, disinfectants may be extensively used in the pails as they are being distributed.

Another great advantage of the midden system is to be found in the diversion of excremental matters from rivers and water-courses. Much sewage at Manchester is thus kept out of the River Medlock. Strange to say, however, the Rivers Pollution Commissioners (Dr. Frankland) state that the sewage from water-closet towns is no worse than that from midden towns. The following is an abstract of the results recorded by Dr. Frankland:—

AVERAGE RESULTS.

	Matters in Solution.			Matters in Suspension.	
	Total Solids.	Chlorine.	Total Nitrogen.	Total.	Organic.
Midden town sewage (37 samples from 15 towns)	57·68	8·08	4·52	27·38	14·91
Water-closet town sewage (50 samples from 17 towns)	50·54	7·46	5·41	31·29	14·36

On this, one question suggests itself—how is it that the suspended matter in the sewage of midden towns is almost identical with that from water-closet towns, seeing that Dr. Frankland states that an average of 25,561 tons of solid matter per annum is annually kept out of the sewers at the several midden towns mentioned. (See Report on Pail System at Nottingham by Dr. Seaton, Society of Arts Conference, 1875, p. 155.)

The pail system may consist either in the use of a little disinfectant or of some absorbent material.

Adopting Mr. Gilbert R. Redgrave's classification of the pan, pail, and midden systems of disposing of sewage (Society of Arts Conference, 1877, p. 33), we shall discuss the subject under the following three heads:—I. Pails without absorbents. II. Pails with absorbents. III. Pails used for the joint collection of ashes and excreta.

I.—PAILS WITHOUT ABSORBENTS.

Of these the Rochdale system (see Society of Arts Conference, 1877, pp. 9 and 33, Mr. Alderman Taylor and others) may be regarded as principal. In support of the non-use of any absorbent, it is urged that to keep out "the profligate associate" is a main object; concentration, not increase of bulk, being the point to be aimed at. The excreta and dry house refuse should be collected at intervals in separate tubs of special construction, the excreta tub being fitted with an air-tight lid, so that transport may be effected without causing a nuisance. The cost per pail per annum is about 5s. 8d. The ashes are carefully screened and sorted.

From the experience of many towns (Rochdale, Salford, &c.) it would appear that two men and one horse (say at a working cost of £3 per week) can remove 600 tubs or pails per week, each pail containing an average of 84 lbs. of excremental matter. This equals 22½ tons per week at a working cost of 2s. 9d. per ton. At Rochdale 10,112 pails were in use in 1882, the weight of excreta collected being 8,518 tons and of refuse ashes 18,396 tons, from 15,289 houses and 237 mills and workshops, with an estimated population of 65,500. In 1881, 552 tons of manure was manufactured. It is calculated that each tub is used by 9·2 persons living in 2·2 houses, the yield being 2·07 cwts. of excreta per head per annum. At Halifax it was calculated that each tub is used by 10·9 persons living in 2·6 houses, the yield being 3·26 cwt. of excreta per head per annum. At Birmingham the returns give from 9·6 to 11·5 lbs. per week per head.

II.—PAILS WITH ABSORBENTS.

In many places, the use of boxes, pails, or tubs, charged with various absorbent materials (ashes, &c.), has been adopted. Numerous substances (see paper in Society of Arts Conference, 1877, p. 49) have been suggested as absorbents. Of these Liebig recommended coarsely powdered bog turf, and Stanford charred seaweed. Stanford claims that seaweed is three times, weight for weight, as effective as dry earth (1 cwt. being sufficient for one month for a closet daily used by six persons). He claims, moreover, that it is easily reburnt, and that the ammonia and fixed salts have been recovered, the charcoal remains as effective as before. Various forms of refuse, too, have been suggested as absorbents, of which may be noted, refuse wool or shoddy, dry horse dung, spent dye stuffs, &c. At certain towns spent dye wood (such as fustic), in the manner suggested by Goux, viz., ramming into a tub by a central core, so as to give a uniform lining to the tub has been employed. Thus splashing is prevented. This method necessitates the frequent removal of the excreta (otherwise the absorbent lining would break down and a semi-liquid mass result), and it is also necessary that the receptacle should be tightly secured before removal to prevent escape of offensive effluvia during transit.

[For a full description of the Goux system, as carried out at Halifax, see remarks by Mr. Councillor Pollard, Society of Arts Conference, 1877, p. 2]. The tubs are packed with screened ashes, soot (cost 50s. per ton) or peat charcoal (£3 per ton), shoddy or mill refuse (cost 2s. 6d. to 7s. per ton), street sweepings, to which sometimes disinfectants are added. The closets are cleared every eight days, except when there is fever in a house, when it is removed every two days. The packing of each tub will absorb from six to eight quarts of liquid. It is said to work satisfactorily. The cost is about 18s. 6d. per annum per closet, whilst the material fetches from 3s. to 7s. 6d. per ton. Dr. Syson (Peterborough) and Mr. Haviland (Northampton) speak in favour of the system, the latter contending that where it has been adopted, the death-rate showed improvement. Any good absorbent that can be obtained at a cheap rate on the spot may be used, *e.g.*, tan. The material after emptying has little smell.

III.—PAILS USED FOR THE JOINT COLLECTION OF ASHES AND EXCRETA.

Of this method the system adopted as Nottingham is a case in point. Here the tub takes the place of the midden pit. It is to be noted, that the ashes are of less quantity in summer time when the chance of nuisance is greatest.

With respect to the mechanical appliances suggested for sifting the ashes, so as to apply only the smaller breeze to the excreta, practice proves them somewhat unsuccessful.

The compost is removed every two or three months and conveyed to the manure wharf, where it is emptied into barges and sold at a price that covers two-thirds of the cost of scavenging.

At Birmingham, where galvanised pails are used to the extent of some 40,000 (representing a population of 250,000), the contents are collected weekly. These are emptied into a vat at the place of deposit, and some sulphuric acid added to fix the ammonia. The contents are passed into a drying machine, consisting of a steam-jacketed cylinder within which are revolving arms, the necessary heat being obtained by burning the cinders and garbage collected in the town. The clinkers are utilised for various purposes.

The process adopted at Manchester, devised by Mr. Leigh and carried out by Mr. Whiley, was described in detail by Mr. Alliott, of Nottingham, at the Society of Arts Conference, 1877 (p. 7, also 37.) The objects are (1) the disinfection of the pail contents by the use of charcoal, produced by charring street sweepings; and (2) the reduction in bulk of the matters so collected. For the purpose of reducing bulk, the liquid in the pails is drained off, and concentrated by a low heat to the consistency of treacle (about one-tenth the original bulk). The heat necessary for effecting evaporation is obtained by passing the products of the combustion of house refuse over the surface of the liquid. (Fryer's concreter.) A certain amount of sulphurous acid is thus generated, which serves to prevent the material from becoming alkaline, whilst the temperature it is said is sufficiently kept under to prevent loss of ammonia. The liquid thus obtained contains 9 to 10 per cent. of ammonia. (Angus Smith). A second variety of manure is made from the fæcal part of the pail stuff, which is also evaporated down to a certain extent. A third variety is prepared from the carbonised refuse saturated with some of the concentrated urine, mixed with fæcal matter; and a fourth variety of manure from the fish and slaughter-house refuse mixed with ashes, urine, and fæces.

I do not propose discussing the pneumatic system of collecting excreta. In certain places on the Continent (Paris, Milan, &c.), the sewage is collected in water-tight cesspools. These are emptied by atmospheric pressure, the contents being forced into moveable exhausted iron tanks, through flexible tubes lowered into the cesspool for the purpose

By this means the escape of noxious effluvia is supposed to be prevented.

The cost of removing the excreta at Paris is about £5 per house per annum. The material is converted at Villette into *poudrette*, great nuisance resulting (Society of Arts Conference, 1877, p. 14). The arrangements of Liernur (which have been adopted in Amsterdam, and to a certain extent in Prague), are, in many respects, similar. Liernur suggests cesspool tanks being placed in the middle of a street, each tank communicating with from fifteen or twenty houses.

The systems of Berlier, partly in use in Paris since 1881, and of Shone, a method of pumping sewage by small pneumatic pumping-engines, the power being generated at a central station, need only be mentioned.

As general rules we consider:—

1. That the removal of the pails should be under the control of the local authority.

2. That on an average they should be renewed once a week, a clean, well washed, pail being substituted for the full one.

3. That air-tight covers should be fitted to the pails before removal, and that they should be conveyed in air-tight vans to the depôt.

The utilisation of the excreta collected in pails is a matter of great difficulty.* At best a low class of manure results, unless some form of concentration be adopted.

Voelcker states that having examined every form of night-soil manure, he never found one having a theoretical value greater than £1 per ton, unless the manure had been specially fortified with guano, or superphosphate, or sulphate of ammonia, &c. The better varieties he valued at from 15s. to 17s. 6d. per ton, whilst those less carefully prepared were not worth more than from 7s. 6d. to 12s. 6d.

THE EARTH-CLOSET.

The disinfecting power of earth has been known from remote antiquity. In China, the formation of a manure by mixing earth with the excreta is of ancient date.

In this country, Rosser, in 1837, proposed the admixture of urine and fæcal matter with earth, lime, &c. The suggestion took no practical shape until 1858, when the Rev. Henry Moule, the vicar of Fordington, investigated the disinfecting and deodorising power of earth on privy soil. As the result, he invented his earth-closet. At his own vicarage, where the cesspool proved to be dangerously near the well, he abolished the cesspool, and placed buckets beneath the pans. Their contents were, in the first instance, mixed with dry sifted earth, earth afterwards being placed in the bucket itself, and the compost left to consolidate in a shed. After five or six weeks he found that the material had entirely lost its offensive odour, and was sufficiently dry to be used again. Thus eventually he not only disinfected his sewage, but produced a manure containing one-third its weight of dry excrement. The next point was the mere mechanical construction of a closet, worked by a handle, with contrivances to secure the application of a proper proportion of dry earth. The earth may, however, be thrown into the closet in one application daily, a method adopted in the latrines at Lancaster, which are under the control of the local authority.

As regards the earth best adapted for the purpose, a well dried clayey earth, that is, a heavy soil loaded with clay, holds the first place; peaty earth comes next, although for efficiency a long way behind a clayey earth. The peaty earth used at the Wimbledon Camp in 1867 was not satisfactory, as it produced a wet and sour compost. Sand and clay are found to have very little deodorising power, and are therefore ill-suited for the earth-closet. The clay soil must be well dried artifically (for in a damp condition its absorbent power is inferior), and after drying, powdered and sifted.

About 4½ lbs. of dry earth per head per day (*i.e.*, 1½ lbs. for each visit, three visits being allowed for each person) is required to obtain a consolidated and unoffensive compost. This quantity was ultimately used at the Dorset County Gaol, the 3 lbs. per head of earth, used in the first instance, being found insufficient. A village of 1,000 persons would need, therefore, about 2 tons of dry earth per day. The dry earth system was used at the Dorset County School, at the villages of Halton and Aston Clinton near Windover, in Lancaster, and at the Wimbledon Camp. In this latter case Dr. Buchanan closely investigated the working of the process.

After the removal of the earth it may be dried and returned to the closet until its manurial value justifies its sale.

As regards composition and value of the product, much will depend on the demand, and on the method adopted in working (*i.e.*, how many times the material had been used). At Lancaster the compost fetched 7s. 6d. to 10s. per cubic yard. At Dorset County Gaol it reached £1 per ton, and at the Dorset County School £2 to £3 per ton. Perhaps 10s. per head of the population annually might be taken as an approximate value.

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* For an account of Milburn's drying machinery, see Society of Arts Conference, 1877, p. 52.

The dry earth system has certain definite advantages over the water-closet. The first cost is less. It reduces the quantity of water required by each household. The closet is less liable to go wrong, to suffer injury from frost, or to be damaged by improper substances being thrown into it. No doubt an intelligent person can manage it, but if it be used in villages it should be managed by the local authority, easy access to the closets by the scavengers being in such case indispensable. Of course a dry earth system does not supersede the necessity for some independent means of removing slops, rain, and subsoil water.

A still further advantage claimed for the earth-closet is the manurial value of the compost, and the ease with which it may be stored until required.

No doubt the earth-closet has its objections. Of these a certain filthiness (real or imaginary), and the difficulties of supplying the necessary quantity of dry earth and of removing the compost, are those chiefly urged. No doubt the collection of material that may be more or less foul as the closet has or has not been attended to by the scavengers, and the after distribution of the compost, compare, at first thought, unfavourably with the cleanliness of water, and the ease with which it serves to convey the filth from the closet to the field. But this assumes (1st) no misadventure of the water-carried sewage between closet and field; (2nd) a farm and a crop ready at all times and seasons—wet or dry, summer or winter—to receive and to appropriate it; and (3rd) no escape of noxious effluvia and miasms, no spread of disease, and no pollution of water courses. How far such assumptions are realised, I shall consider presently.

Earth-closets have been largely used, and their use is rapidly extending, in India, where the drying of the earth is a comparatively easy process. The authorities in India, in 1867, reported to the Secretary of State that Moule's system, which was then generally employed in the barracks, gaols, hospitals, and public institutions of the three presidencies, had been found to be a great public benefit. I can, myself, bear testimony to the excellent results of the dry earth system where the closets are properly attended to—proper earth used—and the materials properly dried.

SEWAGE.

We now turn to water-carried sewage—its composition, value, and treatment.

By the phrase "the sewage of a town" is implied:—

(1.) The excreta (solid and liquid) of the population.

(2.) The refuse from kitchens, laundries, &c.

(3.) The drainings from stables, slaughter-houses, &c.

(4.) The liquid impurities resulting from various trade operations (breweries, dyehouses, fellmongeries, &c.).

(5.) The washings of public thoroughfares, &c.

(6.) Domestic and subsoil water.

To speak broadly, we may define sewage as "the refuse of communities—their habitations, streets, and factories."

It is manifest, therefore, that it is not possible to define broadly what constitutes "average sewage." The quantity and quality of the sewage of a town will be influenced by the following amongst other conditions:—

(1.) The number and nature of the manufactures and trade operations peculiar to the place, and which are drained into the sewers.

(2.) The existence of an excessive number of stables (such as result from the presence of barracks).

(3.) The volume of water supplied to the inhabitants.

(4.) The proportion of rain or surface water admitted into the sewers.

(5.) The quantity of subsoil water that leaks into the sewers.

(6.) The density and general habits of the people.

(7.) The season of the year.

(8.) The time of day.

Sewage may be subdivided into—

1. Domestic sewage.
2. Manufacturing refuse.
3. Rain and storm water.

We shall find, when we come to discuss the treatment of sewage the first great difficulty is the large quantity to be dealt with. It has been suggested to meet this difficulty of quantity by adopting a duplicate set of sewers, the one for sewage proper (domestic and manufacturing), and the other for storm and rain water, or at any rate for the larger part of the rain water. For irrigation purposes, no doubt, it is desirable to have the domestic sewage as little diluted as possible, but for chemical treatment dilution within certain limits is not an evil. A separate system must be more expensive, besides which it robs the sewers of one means of natural and effective flushing, such as occurs after heavy rains. It also excludes from the sewage to be treated many materials (*e.g.*, road washings), that certainly need treatment as much as, if not more than, any sewage proper. To limit the water for removal of filth to its smallest quantity is a sound principle, but there is a danger in over reduction. The most earnest advocates of the separate system scarcely see their way to exclude from the public sewers the rain falling on private property, as this would for the most part necessitate two sets of house drains. It may be admitted that both the separate and combined systems have their merits and defects, and that certain local conditions may determine the choice of the system.

The arguments used in favour of a separate system are :—

(1.) Greater uniformity in the quantity of sewage conveyed.

(2.) The prevention of deposits, the dimensions of the pipes being capable of more accurate adjustment, permitting them to be daily filled to their maximum at the hour of maximum flow.

(3.) If the sewage has to be pumped, expense will be saved by the limitation of quantity.

(4.) Prevention of floodings from the capacity of the sewers being overtaxed, or from obstruction taking place in the surface channels during times of heavy rain, or on the occurrence of a rapid thaw after a long period of snow. Danger arising from the gases in the sewers being forced by the rush of water thus filling the sewer, being driven through the nearest outlet, and possibly through house connections, will be avoided.

(5.) Prevention of precipitation, and so of deposit in the sewers, from earthy matter (such as building lime) being carried in at storm time, together with road detritus, leaves, &c., and which, under ordinary conditions, might not be removed until the next heavy rain.

(6.) If obstruction occurs, a comparatively small volume of water will be sufficient to flush the sewers effectively on account of the relative smallness of pipe.

(7.) That with small pipes, good ventilation of the sewers may be more easily effected.

(8.) That the nuisance arising from organic matters being carried into the pipes at the time of storm, and putrefying on the upper portions of the sewer pipe, where, under normal conditions of flow, it forms a slimy coating and develops swarms of organisms, will be prevented, the sewers being filled daily to their maximum working capacity.

(9.) That the quantity of sewage to be dealt with would be greatly decreased.

On the other side it is urged that, however sound it may appear in theory to urge "the rainfall to the river, the sewage to the soil," there are manifest objections to the separate system :—

1. That it is practically impossible thus to separate rain-water and sewage, things that ought not to be in the rain-water pipes being certain to get there.

2. That the road washings and filth making the first wash of a heavy storm is most often far more filthy than the very worst sewage, and, therefore, specially requires treatment.

3. That storm water is the natural flush water for the sewers.

It may be said that the third objection may be met by automatic flush tanks; the second, by effective scavenging; the first, by educating the people. We have not yet attained the ideal of sanitary work. A separate system would, I fear, mean the intermittent pollution of our water-courses. There are legal difficulties, too, in carrying it out, which I will not discuss.

I do not deal with the question of cost, except to say that the mere size of pipe is not the only, nor is it the main question to be considered in laying pipes, the excavation, paving, &c., being practically the same, whether pipes be large or small.

COMPOSITION OF SEWAGE.

Sewage, we have said, is a complex fluid ;— no absolute average analysis can therefore be stated. It will, however, be a good starting point to regard the average sewage of London as a standard, and to speak of sewage of greater polluting power as a strong sewage, and of less polluting power, as a weak sewage.

A large number of samples of London sewage were examined by Dr. Frankland and myself between 1883 and 1884. The following are certain average details worthy of record. The results are stated in grains per gallon of 70,000 grains :—

	Maximum.	Minimum.	Average.
Matters in solution ..	49·77	28·42	45·213
Matters in suspension	163·9	21·4	48·65
Ammonia	6·527	2·515	3·012
Chlorine............	8·33	5·67	7·21

	Maximum.	Minimum.	Average.
Organic carbon......	3·847	2·118	3·069
Organic nitrogen	2·676	0·964	1·738

Average ratio of N to C — 1 : 1·77.

These results, however, take no note of true storm sewage.

Whilst an assistant of Dr. Letheby, I made, jointly with him, a very large series of analyses of sewage from ten of the large City sewers, the rate of flow being, on an average, 3,500 gallons per minute. The following are average details :—

	Day Sewage.	Night Sewage.	Storm Sewage.
SOLUBLE MATTERS	55·74	65·09	70·26
(a.) Organic	15·08	7·42	14·75
Containing nitrogen	5 44	5·19	7·26
(b.) Mineral	40·66	57·67	55·71
Containing phosphoric acid	0·85	0·69	1·03
,, potash	1·21	1·15	1·61
SUSPENDED MATTERS	38·15	13·99	31·88
(a.) Organic	16·11	7·48	17·55
Containing nitrogen	0·78	0·29	0·67
(b.) Mineral	22·04	6·51	14·33
Containing phosphoric acid	0·89	0·64	0·98
,, potash	0·08	0·04	0·16

It may be of importance to record that at the the time the samples were collected for analysis, 37·5 gallons (6 cubic feet) was contributed per head of the population. Of this, 80 per cent. was represented by the water supply. The following Table exhibits, therefore, the weight in pounds of the chief constituents of 375,000 gallons of sewage (mid-day sewage being taken for comparison) furnished daily by 10,000 people, and its subdivision into excretal and non-excretal refuse :—

Constituents of 375,000 gallons.	From excreta.	From refuse other than excreta.	Total.
	lbs.	lbs.	lbs.
SOLUBLE MATTERS	957	2029	2986
(a.) Organic	733	75	808
Containing nitrogen	200	91(?)	291
(b.) Mineral	224	1954	2178
Containing phosphoric acid	30	16	46
,, potash	34	31	65
SUSPENDED MATTERS	316	1628	2044
(a.) Organic	356	507	863
Containing nitrogen	23	19	42
(b.) Mineral	60	1121	1181
Containing phosphoric acid	21	27	48
,, potash	8	—	8

Putting these results in a few words, we may say every 10,000 persons in London contribute, on an average, 375,000 gallons of sewage daily, and that this includes about 1,671 lbs. of organic matter, containing 333 lbs. of nitrogen, and 335 lbs. of mineral matter, containing 94 lbs. of phosphoric acid and 69 lbs. of potash.

Of course, the total quantity in any given town will depend on a variety of causes. It is certain to be as much as the water supply, but it may be a great deal more. In London, as we have said, it may be taken that 80 per cent. of the sewage is represented by the water supply.

Hofmann and Witt (1857) examined the sewage from the Savoy-street sewer, an average sample being obtained by the admixture of samples taken hourly during the twenty-four hours. The results were as follows, stated in grains per gallon :—

(*a.*) *Organic*	30·70
Containing nitrogen	6·76
(*b.*) *Mineral—*	(?)
Containing phosphoric acid	1·85
,, potash	1·03

A large number of sludge deposits (to which no precipitant was added) have been examined for the purpose of determining the ratio of organic nitrogen to organic carbon. The results are marked by a great want of uniformity, ranging from a ratio of 1 to 3·4, to a ratio of 1 to 9·1.

Major Scott, after a review of a large number of analyses, says, "we may assume that with each [one] part of the three fertilisers, nitrogen, phosphoric acid, and potash, there will be associated in the sewage sludge of London 20 parts, 25 parts, and 56 parts respectively, of organic matter."

Nitrogen to organic matter	1 : 20
Phosphoric acid to organic matter ..	1 : 25
Potash to organic matter	1 : 56

It will be impossible for us to discuss the pollution from sources other than excreta which, together, make up the complex fluid we designate sewage. With respect, however, to stable drainage, I would note that an average horse excretes thirteen times as much fæcal matter by weight, and about fifteen times as much urine, as an adult man. It may be noted further, that both horses and cows produce by respiration about thirteen or fourteen times as much carbonic acid as an adult man, and as a consequence vitiate the air in the same ratio. (Taking 1,200 cubic inches as the quantity of CO_2 produced per hour by a man, 14,750 inches is produced by a cow or horse.)

There is, however, a not unimportant consideration which occurs in considering the character of a town sewage, viz., the feeding of horses. The difficulty of dealing with the stable refuse where the horses have been fed upon maize, is far greater than where the animals have been fed on ordinary corn. In my own experience as a health officer I have had abundant evidence of the peculiarly offensive character of the manure in such cases.

In all inquiries respecting the sewage of a town, the nature and amount of the liquid refuse from manufacturing works (if admitted into the sewers) needs most careful consideration. Of these I may specially mention brewery refuse, the waste being of a singularly offensive nature. To add to the difficulty, a considerable quantity of yeast is discharged with the waste liquor, whilst the high temperature of the refuse intensifies the trouble of treatment. The refuse from certain dye works, &c., are also difficult to deal with.

As regards street washings, the following details may be worth noting:—Granite roads were found at the time of a heavy shower to discharge water into the gullies containing 800 grains of solid matter per gallon, of which 219 grains were in solution and 520 in suspension. The precise composition of the washings, will, however, depend on many conditions, such as extent of traffic, previous period of drought, &c. The water from wood paving, taken about the same time as the above, was found to contain 50 grains of solid matter per gallon, of which 40 was in solution and 10 in suspension. Some 20 samples of road washings taken from all kinds of roads under circumstances as nearly as possible similar to the conditions named above, were mixed together. The water contained 280 grains of solid matter per gallon, of which 120 were in solution and 160 in suspension.

It would be outside my province to discuss the engineering details of a sewage scheme. Yet let me note that sanitary medicine must take cognisance of sewage in its progress through a town. There must be sufficient velocity, as well as an economy of scouring power, in order to prevent the solid matters from collecting. The ventilation of the sewers is again a question of importance upon which authorities differ, and no wonder, seeing how formidable are the difficulties.

Discharge of Crude Sewage into Rivers.

Nothing is more certain than that the discharge of crude sewage into a river is unadvisable. It is, in fact, a method of shifting a nuisance from the nuisance-producer to his immediate neighbour. The evils arising from such discharge depend mainly upon the suspended matter in the sewage. This, first of all, floats about near the outfall, certain portions of the organic matter combining with aluminous compounds from alluvial mud raised by tides and steamers. In time, deposition takes place, In the course of flow the various ingredients are found to deposit more or less in the order of their specific gravity. The first deposits are mainly mineral, with small quantities of organic matter carried down at the same time. The later deposits are mostly finely divided organic matter, along with a small quantity of mineral matter. Thus there occurs, as the result of flow, a natural sorting of the matters in suspension.

The organic impurities of the sewage in this manner collect in the bed of the river and ultimately putrefy. The gases developed and bottled up in time render the solids sufficiently buoyant to rise to the surface where the gases of putrefaction (sulphur and phosphorus compounds for the most part) are given off, the solid matter again sinking to undergo fresh putrefactive changes.

Thus the nuisance from the discharge of sewage into the river may be far more offensive at a short distance from the outfall, than at the outfall itself. Further, at a point of slack water, the nuisance arising from these solids in suspension may be greatly aggravated.

As regards the matters in solution, provided the sewage be sufficiently diluted and allowed a certain flow, complete purification will be effected by oxidation. This fact is now-a-days admitted by nearly all chemists, and need not detain us further. The self-purification of running water is, however, not to be regarded as an argument in support of allowing crude sewage to be discharged into a river.

Before dealing in detail with the value and the treatment of sewage, a few historical details may be permitted.

A Royal Commission was appointed in 1857 (known as "The Sewage of Towns Commission") to inquire into the best mode of distributing the sewage of towns, and applying it to beneficial and profitable uses. Their deliberations lasted for eight years, a preliminary report being made in 1858, a second in 1861, and a final report in 1865. Their conclusions were in favour of irrigation, their belief being that irrigation processes might be made more or less profitable. They say:—

> "1. The right way to dispose of town sewage is to apply it continuously to land, and it is only by such application that the pollution of rivers can be avoided."
>
> "2. The financial results of a continuous application of sewage to land differ under different local circumstances; first, because in some places irrigation can be effected by gravity, while in other places more or less pumping must be employed; secondly, because heavy soils (which in given localities may alone be available for the purpose) are less fit than light soils for continuous irrigation by sewage."
>
> "3. Where local circumstances are favourable, and undue expenditure is avoided, towns may derive profit, more or less considerable, from applying their sewage in agriculture. Under opposite circumstances, there may not be a balance of profit; but even in such cases a rate in aid, required to cover any loss, needs not be of large amount."

In 1862 (*i.e.*, during the life of the previous Commission) a select committee of the House of Commons was appointed (called Select Committee on the Sewage of Towns) to inquire into "the best means of utilising the sewage of the cities and towns of England, with a view to the reduction of local taxation, and the benefit of agriculture." They reported in April and July of 1862.

In May, 1865, the first Rivers' Pollution Commission was appointed "to inquire into the best means of preventing the pollution of rivers." They made three reports, the first in 1866, and the second and third in 1867. In February, 1868, their commission was revoked, a second Rivers Pollution Commission being appointed in April of that year. The subjects embraced in the reports of the two Rivers' Pollution Commissions may be best stated in the language of their commissions. They were appointed "for the purpose of inquiring how far the present use of rivers or running waters in England for the purpose of carrying off the sewage of towns and populous places, and the refuse arising from industrial processes and manufactures, can be prevented without risk to the public health, or serious injury to such processes and manufactures, and how far such sewage and refuse can be utilised and got rid of otherwise than by discharge into rivers or running waters, or rendered harmless before reaching them; and also for the purpose of inquiring into the effect on the drainage of lands and inhabited places, of obstructions to the natural flow of rivers or streams, caused by mills, weirs, locks, or other navigation works, and into the best means of remedying any evils hence arising." This Commission made six reports, the first in 1870, and the sixth in 1874.

In 1875, a committee of the Local Government Board was appointed to make special inquiry into the practical efficiency of the chief systems of sewage disposals then in operation, and for which loans had been sanctioned by the Board. It reported in 1876 (Sewage Disposal, Report of a Committee, 1876):—

> "4. That most rivers and streams are polluted by a discharge into them of crude sewage, which practice is highly objectionable."
>
> "5. That, as far as we have been able to ascertain, none of the existing modes of treating town sewage by deposition and by chemicals in tanks appear to effect much change beyond the separation of the solids, and the clarification of the liquid. That the treatment of sewage in this manner, however, effects a considerable improvement, and, when carried to its greatest perfection, may in some cases be accepted."
>
> "6. That, so far as our examinations extend, none of the manufactured manures made by manipulating town's refuse, with or without chemicals, pay the contingent costs of such modes of treatment; neither has any mode of dealing separately with excreta, so as to defray the cost of collection and preparation by a sale of the manure, been brought under our notice."
>
> "7. That town sewage can best and most cheaply be disposed of and purified by the process of land irrigation for agricultural purposes, where local conditions are favourable to its application, but that the chemical value of sewage is greatly reduced to the farmer by the fact that it must be disposed of day by day throughout the entire year, and that its volume is generally greatest when it is of the least service to the land."
>
> "8. That land irrigation is not practicable in all cases; and, therefore, other modes of dealing with sewage must be allowed."

This being the sewage with which we have to deal, our object is twofold:—

(1.) To make use of any valuable constituents that it may contain; and

(2.) To purify it.

Sanitary requirements however demand that no nuisance should result in the course of the operation of treatment.

The Value of Sewage.

The basis on which the theoretical calculation of the value of sewage may be determined, is, authorities suggest, simplicity itself.

It may be conceded that the animal excreta are, practically, the only constituents of manurial value.

Having determined the value of the excreta of a mixed population, it is only necessary to know (1) the population of any given town, and (2) the quantity of sewage produced during the twenty-four hours, to estimate the manurial value of the sewage. It may appear strange, however, the question being one, we are told, of such simplicity, that authorities before the Select Committee of the House of Commons (1862) should have stated it so variously as from ½d. to 9d. per ton. Certain details upon which these money estimates were founded may be noticed.

The Rivers Pollution Commissioners, who fix its value at about 2d. per ton, say, "The money value of these constituents (combined nitrogen, phosphoric acid and salts of potash), dissolved in 100 tons of average sewage, is about 15s., whilst that of the suspended matters is about 2s. That is to say that 100 tons of average sewage are worth 17s., or about 2d. per ton."

Hofmann and Witt arrived at a similar conclusion. Six-sevenths, they say, of the valuable matters in sewage are in solution. Reckon that 700 tons of sewage contains one ton of solid matter, having a total money value of £6 0s. 3d. (£5 5s. for dissolved matters, and 15s. 3d. for suspended matters), it follows that the one ton of sewage is worth about 2d.

Lawes and Gilbert arrive at a similar conclusion. Reckoning the dry weather sewage of London as 24 gallons daily per head (= 40 tons per head per annum), and the ammonia as 10 lbs. per head per annum, the money value would be 2d. per ton, whilst if the ammonia be taken at 12½ lbs. per head per annum, it would be 2½d. per ton.

Take it, says another authority (Mr. Bailey Denton), that the fertilising elements of one person (worth, let us say, 8s. 4d. per year) are diluted with 61 tons of water (an average quantity contributed by each individual to the outflow from towns), the value of sewage is 8s. 4d. divided by 61, or 1⅝d. per ton.

Such are some of the estimates.

But there were those who desired to be still more precise in their calculations. Authorities who desired to be cautious valued the London sewage, when the population was 3,000,000, at £1,000,000 sterling, that is at the low estimate (ridiculous to many people) of 6s. 8d. as the annual value of each person's excreta. The two chairmen of Parliamentary committees (Mr. Brady and Lord Robert Montagu), after a long inquiry, came to the conclusion that London sewage is equal in manurial value to 212,842 tons of Peruvian guano, with a market price of £2,890,000. Hofmann and Frankland considered that 1,250 tons of London sewage contained the fertilising matters of one ton of Peruvian guano, whilst a very great authority indeed, one before whom the chemical world justly bows in admiration, would listen to nothing less as the annual value of the metropolitan sewage than £4,081,430.*

Such being the teaching of science as to the value of sewage, nothing was more natural than to urge upon authorities its application to land. And here let me say at once, that I distinguish between utilisation of the sewage and its purification. I consider them together, but they are totally different questions.

Science had its story to tell. The land acts, first, as a mechanical filter, and, secondly, as a chemical laboratory. As a filter, the larger insoluble particles are arrested on its surface, whilst the smaller are entrapped a few inches down. The water is absorbed, *i.e.* each earth particle becomes covered with a liquid coating. Now follows the work of the chemical laboratory. The enormous surface of liquid thus formed is favourable to coercing the combination of oxygen with the organic impurities of this subdivided sewage water, carbonic acid and water together with nitric acid, oxidation being assisted possibly by the presence of certain micro-organisms resulting. The organic matters on the surface soon undergo slow burning. The nitric acid is your plant feeder.

The process of slow burning is the work of oxygen, whilst that of nitrification, as the researches of Pasteur and Warrington have shown, is due to the combined work of oxygen and of certain lower forms of life. Hence, to purify, you need not only a flow of sewage but a flow of air, that is, constant movement regulated in its order. As regards the lower organisms, they may be already in the soil or be provided by the sewage. The purifying power of a soil, however, is peculiar to itself. You cannot completely control aëration, although drainage and loosening of soil will promote it, and an excess of irrigation stop it. In fact, the soil as a purifying agent, is to say the least capricious.

Purification, the action of the soil, is greatly assisted by the action of vegetation. In winter time, when there is no vegetation, the soil only must do the work.

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* See Voelcker's report on the "Commercial Value of Sewage and Soil Manures," published in the report of Messrs. Rawlinson and Read to the Local Government Board.

Enthusiasts full of faith were found to embark in private sewage farms, whilst local authorities, anxious to save the rates, offered the sewage to farmers in their neighbourhood for a corresponding return.

It was not long, however, before a certain unpleasant awakening occurred, owing to the farmers declining even to accept the sewage.

Reasons for this were sought. Was it due, as was suggested, to the ignorance of farmers, and their blind attachment to old fashioned ways? This contention was scarcely feasible, seeing how keenly they appreciate newly invented manures (*e.g.*, superphosphate, alkaline nitrates, &c.), new implements, new methods of subsoil drainage, &c.

Men began to suspect one of two things, either that there was (*a*) some obstacle to the agricultural use of sewage; or (*b*) that its theoretical value was very far from being its practical worth.

But other facts than those adduced by the mere working farmer, presented themselves in the failure of the farming attempts of enthusiastic irrigationists. Despite the statement of Mr. Edwin Chadwick, who, in 1844, propounded his views with the authority of the Board of Health, that liquid manure was at all times preferable to solid manure, and suitable for all crops and all soils, we have to record one long series of miserable failures in the attempt to find experimental proof of theoretical estimates. The failure of Mr. Smith's farm (Deanstone), of Mr. Neilson's farm, of Mr. Telfer's farm, of Mr. Kennedy's farm (Myremill), of Mr. Huxtable's farm, of Mr. Chamberlain's farm, of Mr. Littledale's farm, and of Mr. Mechi's farm (all of which cases have at various times been held up as wonderful illustrations of the money success of irrigation) supply the unanswerable answer to Mr. Edwin Chadwick and his school.

The Rugby farm was pronounced "unremunerative" by its first manager (see Mr. Campbell's letter, *Times*, Nov. 18, 1864), whilst it was abandoned by Mr. Congreve, and by Mr. Walker who succeeded Mr. Campbell. The story of one and all sewage farms is a history of commercial failure.

The irrigationists, however, still pointed those who doubted the commercial success of sewage farming to the Craigentinny meadows in Edinburgh. We were told (correctly no doubt) that in good seasons £20 to £30 worth of green produce had been realised per acre (say £25 average). But it is no secret,

(1.) that in these meadows the quantity of sewage used has been from 10,000 to 13,000 tons per acre, in other words, taking the produce as worth £25, the sewage employed had a value, irrespective of rent and farming expenses, of less than ½d. a ton.

(2.) That the sewage was not used continuously, and when not wanted on the land, was diverted into the sea.

Nothing is more certain than that the theoretical value calculation of sewage, based on the supposition that the manurial elements of a sewage, extracted and dried, are their value in solution, must be regarded as an extravagant dream of enthusiasm. Such calculations have entirely overlooked the effects of dilution, and the presence of a mass of worthless material. Nay more, the "profligate associates" as they have been called in sewage, are not merely worthless, but worse than worthless. Sewage in this respect is not singular. Thus whilst rotten farmyard manure may have an estimated value of 15s., its practical value rarely exceeds one-half its theoretical. No doubt the enthusiasts of a few years ago have learnt a lesson at some cost. Mr. Bailey Denton, admitting the fallacy of old calculations, still clings with praiseworthy consistency to some of his old ideas of value. "Even," says he, "with such a greatly diminished value (*i.e.*, 1⅝d. to ¼d. a ton), the country has a valuable property which it is our duty to preserve."

We are constantly reminded, moreover, of the success of irrigation in India, Egypt Persia, &c. The simple application of water to the soil in dry and warm climates increases fertility. Moreover, we must admit that sewage has a higher manurial value than mere water. But the cases are not comparable; a climate having the temperature of our own with frequent rain (rain falling 150 days, on an average, out of 365), is not to be compared with one of tropical heat and of long continued drought. The sandy soil of Gennevilliers or of the Dantzic farm are no cases in point. Admitting as a fact a certain manurial value in sewage, the English farmer, it is certain, would sooner sacrifice the manurial value than be compelled always to have the water. For two difficulties stare him in the face (and a sanitary authority demands these conditions), first, to be compelled to take the sewage at all times (day and night, Sundays and week days) all the year round (summer and winter) whether his soil wants it or not, or whether he has any crops or not that can profitably use it, at all stages of their growth, seed time and harvest, and, secondly, so to utilise it as to produce an effluent which at all times, all the year round, shall neither produce a nuisance nor pollute a public watercourse. In times of frost—during the heavy rains of spring and autumn—the farmer finds he has no alternative (his land being practically impenetrable) but to let the sewage pass away unpurified into the nearest stream. He finds, too, that the use of sewage again is prejudicial during the maturity and ripening of the crops. These difficulties were grasped by the Parliamentary Committee of 1862, who reported, that "it was desirable that those using sewage should have a full control over it, so that they might apply it when and in what quantities they may require."

Local authorities have, indeed, learnt the truth of these statements, since when they adopt an irrigation scheme they know that it is necessary for them to acquire land, and not trust to the farmers in the neighbourhood.

I am aware that the difficulty of frost is supposed to be met by the increased temperature of the sewage. If time, however, be allowed for the ground to be aërated, and the weather be so cold as to freeze it, some of the sewage at least must flow over frozen ground. This is the dilemma. Adopt means to aërate your ground, and it will become frozen. Neglect to aërate your ground, and it is useless, or practically so. The difficulty of storm water is said to be met by a certain portion of land being kept for storm sewage, and possibly planted with osiers. But this does not meet the case. Your osier beds can become waterlogged as well as your farm. It is no doubt an advantage to have a reserve, but it only meets a part, and a very small part, of the real difficulty.

In considering the question of working cost, quite apart from the expense of preparing the and, it is stated on good authority (Local Government Board Report, p. 33), that sewaged land requires more horses and double the amount of manual labour than ordinary arable land. This means greater capital. "To properly stock (I am quoting from the report) and work a sewage farm upon which the main produce is consumed, quite five times the usual amount of money will be needed."

There is another point to be recorded, the enormous care needed in the management of a sewage farm. Dr. Carpenter understands this when he laments "how mischievous people often break down the carriers and other works, and let the sewage run where it ought not to go—in that way, getting into the effluent water."

We have admitted a certain manurial value in sewage. Before we proceed to consider the question of producing a good effluent, some other points bearing on its fertilising powers come before us, viz. :—

(1.) The methods of applying sewage to land.

(2.) The soil best suited for irrigation.

(3.) The crops most suitable for a sewage farm.

(4.) The value of the crops so grown.

I.—THE METHODS OF APPLYING THE SEWAGE TO LAND.

Various methods have been suggested, such as simple broad irrigation, as practised at Milan, converting the field into a water meadow; and subterranean irrigation, pipes being laid sufficiently deep to be beyond reach of the plough. This may be called upward irrigation. Both of these plans have been tried and abandoned. Irrigation by hose and jet is no doubt that method of applying sewage which yields the best results. (Smith of Deanstone, Chadwick, Mechi, Telfer, Kennedy.) Professor Way says, "If you ask me how to make, regardless of cost, the manurial ingredients of the sewage into the greatest amount of produce of any kind, I would put it on with pipes and hose in small quantities almost as I would in garden cultivation, as if I were watering it with watering pots, but it would never pay you to do it." And, apart from this, you would never be able to get on the land the quantity that would meet the sanitary difficulty. This failing, sewage has to be brought to the highest points of the land to be irrigated, conveyed by carriers of a more or less permanent character into some form of sewer channels. The open carriers, or surface channels, may be mere trenches, or, if it be desirable that they should be placed above the ground, constructed of concrete or of sheet iron, the sewage flowing in large or small volume, as required, upon the surface of the ground. Sometimes moveable troughs are used (Carlisle), but usually the sewage is run through open carriers, and merely the land more or less flooded by the carriers being dammed up at certain parts. Simple contrivances only are required to turn on or turn off the sewage as needed. The land must of course be so levelled and drained that the sewage may flow over different portions of ground, and not into hollows where it would become stagnant, or pass away without undergoing the needful purification.

II. The Soil best suited for Irrigation and Filtration.

We may distinguish three cases :—

1. Very porous soils.—A pure sandy soil has had its advocates, on the ground that it becomes richer every year that sewage is applied to it, irrigation thus serving to convert poor into productive land (Way). Bagshot-heath has found favour as sewage land with some, on the ground of its porous, sandy, and sterile character (Lawes; Paxton). In such soils, however, the effluent is generally very impure. A coarse, gravelly soil may be "free," but it most certainly, as a rule, discharges the sewage imperfectly purified, on account of its non-retentive nature.

2. Heavy clay soils, or rather soils containing a notable proportion of clay, were approved by Liebig, on the ground that clay was the most effective soil for absorbing the valuable constituents of sewage, viz., the ammonia, phosphoric acid and potash. Liebig considered the success of the Craigentinny meadows to be dependent on the clay in the soil. It was his opinion that if the Maplin sands were to be used as irrigation land, 2,000,000 tons of clay would be needed to give them fertility to the depth of one inch.

A soil containing such a proportion of clay as to retard over-much the passage of the sewage through it, acts injuriously; in other words, it is over retentive—the fact being that, to get the best effect of filtration, the filtration must not be too slow. The effluent is in such cases usually turbid and discoloured.

A clay soil (*e.g.*, London clay, the stiff clay beds of the new red sandstone, and the boulder clay overlying the Oxford clay) are impervious to water. Such ground may be utilised by burning and mixing, although the cost of such treatment is considerable.

With clay, therefore, we may have either very slow filtration, the effluent being coloured and turbid, or practically no filtration at all. Further, such soils are specially liable to crack and fissure, both by frost and extreme heat; in either case the sewage would run through the soil in an absolutely unpurified condition.

3. Soils intermediate between sand and clay. Perhaps a sandy loam, or a loam with a small proportion of clay, is that soil best fitted to yield a good effluent where irrigation or filtration through land is practised. Bailey Denton points out that the capacity of soils to absorb water (*e.g.*, a coarse gravelly soil) is no criterion of its cleansing capability. On the contrary, he says, a loamy soil having sufficient sand to render it free and "to fill it with close interstitial spaces for æration, will discharge a superior quality of purified water by the under drains." The best results I have myself seen are in the case of soils containing about 86 to 90 per cent. of sand with a little clay.

The value of a plant-bearing soil as an absorbent, and possibly as an elaborator of plant food, is worth considering. Way supposed the absorbent action of a soil to be dependent on the chemical action of certain silicates of lime and alumina, which fixed the alkaline bases and allowed the acid constituents (phosphoric acid excepted) to pass in combination with lime. Liebig states that an acre of common clay soil, 4 inches deep, in the neighbourhood of Munich, would absorb 2,076 lbs. of ammonia, 1,910 lbs. of potash, 888 lbs. of phosphoric acid, and that, like the stomach which fitted food for the wants of the animal, such a soil fitted sewage for the wants of the plant. Clay, in his experiments, was the best soil for irrigation, sand the worst, turf and peat being intermediate. Voelcker found that clay absorbed potash salts and ammonia freely from its solution, but never completely, the ammonia absorbed being, in great part but not entirely, capable of removal by washing. Sand absorbed ammonia and potash salts imperfectly. Chalky and marly soils absorbed and rendered insoluble the soluble phosphoric acid more powerfully than either clay or sand.

Voelcker's experiments on the action of various soils on ammonia (*Journal of the Royal Agricultural Society*, xxviii. p. 544) show—

A.—As regards free ammonia :—

1. That all soils absorb ammonia from their solution, but that no soil absorbs it completely.

2. That the stronger the ammonia solution, the larger the absolute quantity of ammonia absorbed, whilst the weaker the ammonia solution, the larger the relative quantity of ammonia absorbed.

3. That if, after the saturation of a soil with a weak solution of ammonia, a strong solution be applied, the soil will absorb more ammonia from the strong solution.

B.—As regards salts of ammonia :—

1. That the soil absorbs the ammonia, the acid of the salt combining with the bases (lime, magnesia, &c.) present in the soil.

2. That absorption is greater with strong

solutions of ammonia salts than with weak solutions.

The ammonia absorbed by the soil may be partly removed by washing with water, but the quantity capable of being thus removed is always relatively less than that retained by the soil—in other words the absorptive power of the soil to absorb ammonia is relatively less than the solvent power of water to redissolve it.

These remarkable results are chiefly dependent on the alumina and hydrated oxide of iron in the soil, and in lesser degree on the presence of lime and other bases.

I wish to remark on the immense advantage in an irrigation farm of ferruginous earth. I have seen a case where a very good effluent was obtained by the accidental circumstances of a small area (small, that is, in comparison to the entire farm) containing a large quantity of on iron deposit.

The composition of irrigated as compared with non-irrigated soils has been on many occasions contentious matter in our courts, and the subject of numerous investigations. The top few inches of an irrigated farm presents no doubt a very marked difference from the underlying soil, such difference being dependent partly on the nature of the soil, partly on the method of irrigation, but more particularly upon how far the suspended matters have been removed before the application of the sewage to land, and the extent to which intermittency of action has been practised. If, however, the top inch of the land be carefully scraped off, the difference of the composition of sewaged and non-sewaged ground will probably be found to be small. As regards nitrates, phosphates, and chlorides, the difference is, as a rule, absolutely *nil*. Perhaps there may be a slightly increased amount of oxidisable organic matter, but even this is by no means invariable, whilst at a depth of eighteen inches, it is a very rare thing to find any marked alteration of composition. It is certain, therefore, that given land of ever so suitable a character as a sewage purifier, its powers are not those, agriculturally, of a storage battery.

Any excess of sewage over that which the plant can utilise at the time is, so far as commercial profit is concerned, wasted, passing off into the subsoil drainage partially or wholly purified. As a fact, the land does not store in any quantity the manurial elements for the use of future crops. The fertility of a given area is not 10 times greater by the application of the sewage of 1,000 persons, than it would be by the application of the sewage of 100. In fact it is no better and no worse. The difference is to be sought in the effluent, not in the land. The Craigentinny meadows are still sandy and poor, despite of all the sewage put upon them. The land, notwithstanding all that has been done for it, still contains less than fifteen parts of organic matter in a thousand.

But how far is absorption dependent on the strength of the manurial fluid applied? Voelcker's investigations on this point have been referred to in detail. His experiments show that when manurial elements in a weak solution like sewage is applied to the soil, it merely oxidises the nitrogen and strains the fluid, the resulting nitrates flowing away, unless vegetation is growing at the time, when the elements of the sewage may be appropriated. But more than this, his experiments show that a weak sewage may actually remove from a soil upon which there is no vegetation the manurial ingredients already present in it.

That the total soluble nitrogen of sewage may be found in the effluent as nitrates when the sewage is applied to land where there is no vegetation or where vegetation is inactive, I have many times verified by analysis. (See Table, third report of Commissioners appointed to inquire into the best mode of distributing the sewage of towns, 1865, p. 46, showing as the result of sixty-two analyses, that the drainage effluent water contained on an average the same amount of organic and inorganic constituents as the sewage.)

III.—CROPS MOST SUITABLE FOR IRRIGATION.

Nearly all agree that the most profitable application of sewage is to pasture land, osiers, and Italian rye grass. Way says that its application to grassland is the only profitable way of dealing with it—in other words, by feeding it into milk or flesh, and so getting a manageable manure.

Bailey Denton* holds a different view considering that "the less the sewage farmer has to do with stock the better." He is of opinion that the cultivation of grass is unprofitable.

And here I may refer to the greediness with which cattle feed on sewage irrigated pasture. Mechi states that cattle will follow the hose and feed on the grass wet with sewage. Many who gave evidence before the Parliamentary Committee on the sewage of towns testified to the same effect, the Committee reporting that "the evidence proves that cattle of all sorts appear to prefer sewaged grass to all others, and will eat it within a few hours of its being dressed with sewage." And I beg your attention to this fact in passing, for I shall refer to it again when I speak of the dangers incident to eating the meat of animals fed on sewage produce.

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* See Lecture to Maidstone Farmers' Club on "Sewage Irrigation as a Means of Disposal of Town Sewage."

I would note, too, that there is evidence to show that a damp and sodden condition of ground, such as is common in a sewage farm, is peculiarly favourable for the production of the "liver fluke" of sheep (*Diatoma hepaticum*), a disease occasioning great fatality. This danger of irrigation is not undeserving of attention.

Roots.—Some have advocated irrigation for root crops in dry weather (Campbell, of Rugby). The mangold-wurtzel does well in a sewage farm.

Miller, of Edinburgh, is against the use of sewage for roots, since he found it made furrows and channels in arable land, and washed the roots of plants bare.

Bailey Denton advocates the growing of roots (mangolds, beet, turnips, carrots, parsnips, potatoes, and onions) as better crops for sewage land than the cultivation of grass.

Cereals.—Some consider sewage suitable for wheat. Mechi advocated its use, although not directly to the land so used (otherwise the wheat grows too luxuriantly and fills too easily) but to a preceding grass, root, or clover crop.

The majority of authorities disapprove of its application to arable land, or of its use for cereals, roots, &c. Voelcker says, "It is quite unfit for cereals after the grassy state, because of its forming straw instead of grain, and checking the ripening process." Lawes, Way, Congreve (of Rugby), have expressed themselves to much the same effect. (See also evidence before Select Committee of the Sewage of Towns, 1862.)

Its application to corn crops was tried at Watford, Rugby, and Alnwick, but abandoned.

Bailey Denton advocates the production of straw upon a sewage farm as advantageous for feeding stock, although the quantity of grain is small.

Voelcker condemns its use for market produce, "as it clogs the soil and kills the plant."

Bailey Denton specially advocates the cultivation of cabbages on sewage farms. I remember being told that they had tried growing rhubarb at Aldershot, but that they abandoned it because nobody would eat it a second time, owing to its rank sewage flavour.

At the Brussels International Congress (1876) a collection of vegetables were shown, said to have been grown in fields irrigated by the sewage of Paris. There was a curious silence as to the cost of production.

Liebig, arguing on the quantities of ammonia and phosphoric acid in sewage, in comparison to the quantity of potash, considers sewage less adapted for grass crops than for pasture land. Say 4 tons of good hay (= 12 tons of grass) is grown on an acre of land per annum. This 4 tons abstracts from the land:—

Nitrogen......	141·6 lbs.	(= ammonia 172 lbs.)
Phosphoric acid	72 ,,	
Potash	124 ,,	

To get 124 lbs. of potash you must have 2,400 tons of sewage. This contains:—

Nitrogen......	451·07 lbs.	(=ammonia 547·73 lbs.)
Phosphoric acid	109·6 ,,	
Potash	124 ,,	

Now, in accordance with the law that "the effect of all the constituents of a manure is but the effect of that one of them which, in comparison with the wants of the plant, is present in the smallest quantity," it follows that 375·73 lbs of ammonia, and 37·6 lbs. of phosphoric acid, are not merely wasted, but act injuriously by clogging the soil and killing the plants. On this ground he advocates adding to the sewage potash and phosphoric acid in proportion to the requirements of the crop, thus lessening the sewage required, and increasing general fertility. Thus Liebig argues that sewage should always be used in conjunction with richer manures, guano being rich in phosphates and ammonia, but poor in potash; farmyard manure being rich in potash, but poor in phosphates and ammonia; sewage occupying an intermediate position. The following Table will serve to illustrate his views:—

	Potash lbs.	Phosphoric acid. lbs.	Ammonia lbs.
193 tons of sewage yield	10	8·8	44·1
2,023 lbs. of farmyard manure .	10	9·0	14·9
1,672 lbs. of Peruvian guano ...	10	200·5	142·3

Voelcker scarcely endorses these views, for he says if the soil itself contains the elements of fertility, sewage has no more value than so much water; but if it be poor and barren, then the application of sewage will produce crops of grass when nothing else of any agricultural value will grow upon it.

IV.—Value of Crops grown on Sewage-irrigated Farms.

It must be admitted that the size and weight of roots and succulent vegetables grown on a sewage farm are often considerable. Thus enormous cabbages, turnips, celery, &c., are often shown as sewage-grown. But sewage produce is best described as dropsical, *i.e.*, the per-centage of moisture in sewage-grown produce is far higher than in the case of ordinary market produce. (This fact was proved by Lawes in his experiments at Rugby Farm.) This being the case, sewage produce is difficult to dry, and prone to decompose. It must be consumed fresh, and on the spot, for it will not stand being carried any distance to market. Dr. Voelcker is definite on this point. Irrigated land, it is certain, does not yield so nutritious a product as natural pastures. If you want good produce, you must be content with small quantity.

Passing to the solid matter itself, a larger proportion of nitrogen was found in the sewaged than in the unsewaged produce, and the larger the quantity of sewage applied, the larger became the nitrogenous constituents of the vegetation.

Per-centage Composition of Dry Substances.

	Plot I. No sewage plot.	Plot II. 3,000 tons sewage per acre.	Plot III. 6,000 tons sewage per acre.	Plot IV. 9,000 tons sewage per acre.
Nitrogenous substances	11·16	17·58	18·37	19·66
Fatty matter (ether extract)	3·41	4·13	3·95	4·04
Woody fibre..................	29·08	28·21	28 32	28·13
Other non-nitrogenous matters ...	46·73	39·09	38 08	36·91
Mineral matter (ash)	9·62	10·99	11·28	11·26

But here arises the important question, "Are nitrogenous constituents the true measure of the nutritive quality of a produce?" To this Voelcker replies, "No." On the contrary, nutritive properties depend on proper maturation, whilst an excessive quantity of nitrogeous produce indicates unripeness, *i.e.*, a deficiency of sugar.

The Birmingham Sewage Inquiry Committee (1871) refer to the difficulty of disposing of the rye grass of the 140 acres of the Corporation Sewage Farm at Saltley, as an argument against the possibility of disposing of the produce of 4,800 acres it was at that time proposed to acquire. The difficulty of finding a market for the produce is the difficulty after you have encountered the preliminary difficulties of getting the produce. Ricks of rye grass and coarse hay are often to be found on the sewage farm, untempting to the buyer, but serving to swell the balance sheet of the farm by being entered as so much to the good.

Fattening power of sewage grass.—This question was made the subject of experimental investigation on ten Hereford oxen, two being supplied with unsewaged grass, and eight with sewaged grass from land irrigated with 3,000, 6,000, and 9,000 tons of sewage per acre per annum. The reporters state the grass (sewaged or unsewaged) was not well adapted for the fattening of oxen without the addition of other food, such as oil cake. The two fed upon unsewaged grass increased 2½ lbs. per 1,000 lbs. live weight per week, and the eight fed on sewaged grass (of which a greater quantity was consumed per head per day than in the former case) increasing at the rate of 2¾ lbs. Such oxen, however, should yield, if fed on good fattening food, 9 lbs. to 10 lbs. increase per 1,000 lbs. live weight per week.

Experiments with milch cows.—Experimenting on twelve cows, ten being fed on sewaged grass and two on unsewaged grass, the experiments clearly indicated that considerably less fresh unsewaged grass was required to produce one gallon of milk than fresh sewaged grass, and that a given weight of the animal was more productive when fed on unsewaged than on sewaged grass—but that a given weight of dry substance supplied in sewage grass was more productive than an equal weight supplied in unsewaged grass. The experiments with the rye grass, as regards milk production, are inconclusive.

The chemical analysis of the milk from cows fed on sewaged and unsewaged grass does not indicate any material difference.

But a case before the courts suggests that the milk of cows fed on sewaged grass is more apt to become sour than from cows fed on unsewaged grass. The cases are few indeed, if there be any, where the keeping milch cows on a farm has really proved profitable.

I have thus far limited myself almost entirely to a consideration of the manurial value of sewage. We must now consider, in connection with manurial value, the second condition of effective sewage treatment, viz., the production of a good effluent.

There now arises the important question, how much sewage can properly (*quâ* agricultural success) and safely (*quâ* sanitary success) be applied to a given area of land.

There are two ways of applying sewage to land—

1. Surface irrigation, or the distribution of sewage over as many acres as it will wet, having in view a maximum plant growth.
2. Intermittent downward filtration.

I.—SURFACE IRRIGATION.

And here one fact is certain, the agricultural and the sanitary aspects of the question are not in accord. To realise an agricultural success the farmer says, apply at proper times and seasons a large quantity of sewage (and within reason the larger the better) to your land. To realise a sanitary success, the sanitarian says, apply continously as small a quantity as possible. If sewage be put upon a soil in larger volume than 1,500 tons per acre per annum, even when there is actively growing rye grass upon it, the subsoil water is certain to pass away foul (Way). It was found at the Anerley School farm that the same crop of grass was obtained when 1,500 tons of sewage per acre was applied by hose and jet, as when 8,000 to 9,000 tons were supplied by open carriers, but that in the latter case the effluent water was almost as foul as the sewage (Westwood). At Rugby, it was recorded that with 3,000 tons of sewage per acre, a yield of 22 tons of grass was obtained, whilst with 6,000 tons of sewage a yield of 28 tons of grass, and with 9,000 tons of sewage a yield of 32 tons of grass only was obtained (Lawes). The conclusion is irresistible. There is a limit to the quantity of manurial elements that the soil and plants are capable of appropriating. Exceed this limit, and any quantity in excess must pass away in a more or less unoxidised form.

As regards the quantity of sewage that is safe and proper to apply to land, I find authorities differ between 100 tons and 40,000 tons per acre per annum; a difference, in other words, between 2 and 800 persons per acre. Thus an authority "of great weight" expresses an opinion that 300 tons of sewage per acre per annum would accomplish as much as the 10,000 tons he had applied. Another authority considered the Rugby farm inferior to the Edinburgh meadows, because in the former from 3 to 9,000 tons of sewage per acre only was applied, whereas in the latter 10 to 12,000, and even 30 to 40,000 tons have been used. Mr. George Shepperd and Mr. Mechi considered 100 tons of sewage per acre per annum sufficient (or the manure of two persons). The latter lived to find his estimate erroneous, increasing his quantities at first to 500, and finally to 2,000 tons per acre for green crops. Miles, of Bristol, reported that two persons per acre gave good results, whilst Mr. Thomas Ellis considered (and in this Mr. Brady, the chairman of the Select Committee on Sewage, agreed) 600 tons of sewage (or the produce of a dozen people) advisable.

Mr. W. Hope and Mr. Westwood, of the school farm at Anerley, considered an acre of land was required for every twenty or thirty people (1,000 to 1,500 tons of sewage per annum), for, said Mr. Westwood, "if more than this be used, it runs away into the drains and fouls the stream." This he found to be the case when 8,000 or 9,000 tons per acre was applied to land cultivated with rye grass. Liebig considered 2,430 tons of sewage sufficient for meadow land to yield 12 tons of grass (4 tons of hay) per acre. He adds, a soil saturated with manure not only fails to increase the crop, but, in the case of roots, is positively hurtful. The Earl of Essex (Chairman of the Commission to inquire into the best method of utilising sewage), after many trials at Watford, decided that 5,000 to 6,000 tons a year was desirable to each acre for Italian rye grass, but that 600 tons to each acre was sufficient in the case of meadow land. Voelcker fixes 2,000 to 4,000 tons per acre for better kinds of land, and 8,000 to 10,000 tons for sandy soils, stating "that he has nowhere seen such small quantities as 300 or 400 tons per acre produce any remunerative effect." Way likewise fixes 100 persons to the acre, provided the land be grass land, estimating that 30,000 acres of land would be required if the sewage of 3,000,000 people had to be dealt with.

Sir R. Rawlinson states the case thus:—"The means which have been found in practice to answer are as under stated, namely, for flood irrigation about one statute acre to 100 of population of a fully water-closeted town, but there cannot be any hard and fast rule." (Suggestions, 1878.)

In nineteen irrigated towns, according to Professor Robinson (Sewage Disposal, p. 79), there is an average of 137 persons to each acre (= to 5,128 gallons per acre per day, or 38 gallons of sewage per head of the population per day). Mr. McKie, of Carlisle, records the average of 53 towns as 98 persons to each acre (= to 3,826 gallons of sewage per acre per day).

Lawes and Rawlinson also agree that an acre of land is required for every 100 people (or 5,000 tons of sewage per year), a view agreed to in the main by Bailey Denton, who fixes 100 to 150 people according to the porosity of the soil, lighter soil taking the sewage more freely than heavy. In Bailey Denton's opinion, however, extra land is needed for giving rest, and for permitting alternate cropping.

The difficulties, it will be seen, are tremendous. For commercial profit the sewage must not be less than 5,000 tons per acre—for sanitary efficiency (*i.e.*, to prevent nuisance), the quantity must not exceed 1,500—*i.e*, a minimum of 100 is necessary to pay—whilst 30 is the maximum to escape prosecution.

II.—INTERMITTENT DOWNWARD FILTRATION.

The difficulty of securing efficient land for surface or broad irrigation pressed hard on the irrigationists. Dr. Frankland and others saw that the larger the population of a town, not only the less land there was within a reasonable distance, but the more costly such land became. Irrigation was doomed unless the land difficulty could be overcome, and some method adopted whereby a large volume of sewage could be concentrated on a small area.

Dr. Frankland's laboratory experiments of 1870, with known quantities of different soils, gave birth to the process known as "Intermittent Downward Filtration." For this purpose it was stated to be necessary—(1) to have a suitably constituted soil which will act as a filter: that is, a soil not too open, so that anything may pass through, but not too close, so that nothing may pass through. (2.) To have the land deeply drained, say at a depth of 6 feet, so as to allow a considerable distance for percolation. This constituted filtration as opposed to irrigation. The land becomes an oxidising instrument, to burn the impurities, and so transform them into harmless gases, rather than a mere separating machine. To obtain the best effects of oxidation, and to keep the land in the most effective condition, the sewage must be applied intermittently, *i.e.*, with regulated intervals of rest, to give time for air to go into the ground as the water runs out, thus fitting it for a fresh dose of sewage. Intermittent filtration, Dr. Frankland would say, is a copy of nature in the lung action of respiration, alternately receiving and expelling air. This intermittent work avoids, he would contend, the clogging of the soil, and secures its efficient and frequent æration. By such means Dr. Frankland stated that the sewage of 3,300 people could be treated on one acre of land.

Let me endeavour to give an illustration of the method of working the intermittent downward filtration system.

Suppose a population of 9,900, with three acres of suitable land suitably drained Each acre, for purposes of work, is subdivided into four parts, the sewage of 3,300 being placed successively for a period of six hours on each quarter acre. Thus each quarter acre receives the sewage of 3,300 people for six hours, eighteen hours rest being allowed before it receives another dose. Some have suggested, in further development of the idea of intermittency, that one of the three acres might be used per year for the 9,900, so that each acre would have two years during which it might the more perfectly recover itself, whilst each quarter acre of the one acre in use for the year would have eighteen hours rest out of the twenty-four. It is no misnomer to call this "intensified irrigation."

But Dr. Frankland's arguments were based on laboratory experiments. The varying effects of the varying qualities of sewage on the one hand, and the enormous differences in land, as regards its capability of absorption and filtration on the other, seem to have been very imperfectly considered. Nor were the difficulties arising from subsoil water taken into calculation, nor the density of the soil in the laboratory experiments, as compared with its density in the natural state. I am fully aware that Dr. Frankland would say that the estimate of 3,300 to an acre supposes proper land—properly drained—properly levelled.

It is right, too, we should note that Dr. Frankland has from the first insisted that intermittent downward filtration involved the sacrifice of the manurial value of the sewage, the area of ground being too small, and the quantity of sewage too large, to make it pay. This view, however, Mr. Bailey Denton in no way endorses; on the contrary, he considers that the system of the intermittent application of sewage to land in no way interferes with, but actually assists, farming operations.

Both Dr. Frankland and Mr. Bailey Denton agree in considering the removal of the suspended matter in the sewage before its application to the land to be unnecessary. Mr. Bailey Denton, however, advocates the use of furrows (rather than flooding the land), partly as a means of preventing the clinging of solid sewage matter to the stalks and leaves of plants, and partly with the object of bringing the sewage into contact with the roots, which are the active abstracting agents of manurial worth. Indeed, Bailey Denton goes so far as to say that the presence of the suspended sludge in the sewage is an advantage rather than a bar to its application to land. By making some furrows of greater depth than others, he renders these the receptacles of the solid matters. The sludge, he says, "consists of vegetable and animal substances which are perishable, mixed with earthy and mineral substances which are not perishable." It is only necessary to remember this "to realise the fact that they cannot possibly clog the land when dry. The most minute particles consist of fine road sand which floats on in the liquid after the heavier detritus has deposited itself. When these perishable and imperishable substances find their way into the soil, they must each, from their nature, obviously add to its porosity, inasmuch as the perishable substances leave open spaces as they decay, whilst the imperishable substances from their gritty nature necessarily help to increase its filtering capabilities. So long as the sludge is wet it impedes absorption to a certain extent, but when once dried and the land broken up by the plough, it not only ceases to uphold the liquid, but naturally and permanently helps to let it into and through the soil." In other words, by digging the sludge into the soil, Mr. Denton contends that the soil is rendered more percolative than before. There may be something in this view. But how often have we seen, in practical working, sewage being applied to land, clogged by large masses of black albuminous matters, the result of previous irrigations, closely adhering to the soil, impeding absorption, and lessening the surface through which the water can pass into the ground. Mr. Denton says, "the sludge must then be allowed to dry, and when in a fit condition dug in." But in the act of drying comes the nuisance. In hot weather it means putrefaction (Mr. Denton calls it decomposition of perishable substances), and with putrefaction comes a stink, besides which it is in the act of evaporation that dangers occur from detrimental matters being carried bodily into the air. In filter beds, we know full well that the surface of the filter bed is that part most affected, and further that, for efficiency, the surface of the filter bed needs frequent removal and cleansing, whilst irrigated land shows neither to the eye nor to chemical analysis much indication of any excess of organic impurity a few inches from the surface.

Let us take two cases by way of illustrating the practical working of intermittent downward filtration:—

The Merthyr Tydfil farm, with its 50 feet of gravel soil, may be taken as pattern ground for the system. Nothing, moreover, was spared to make it a success under the able advice of Mr. Bailey Denton. The mean depth gave two cubic yards of drained soil for every square yard of surface. The cost of preparation was very great. But how about number to the acre? Is not the actual number of persons per acre more nearly 1,000 (I think I am much overstating it) than 3,300? Is not the sewage of Merthyr very dilute by reason of its admixture with subsoil water?

At Kendal again, Mr. Denton, in 1873, advised the purchase of 16 acres of suitably constituted soil, upon which to treat the sewage of 13,500 persons, with a mean dry weather discharge of 975,000 gallons. The Council, with the Report of the Rivers Pollution Commissioners before them, deemed Mr. Denton's suggestion of 16 acres extravagant. If, said they, one acre will do for 3,300, why advise 16 acres for our 13,500, of which very few (probably not one-third) contribute sewage. The Council, however, decided to be liberal, and advised the purchase of 5½ acres of land. The cost of the Kendal sewage farm was £16,371 (I quote from an official document); and the cost of laying out the filter beds £1,400, *i.e.*, about £280 per acre. But can the Kendal effluent be deemed a success? Some 11 acres have been added since 1880. The Council have let the land, and I fear the process adopted can scarcely, at the present time, be regarded as intermittent.

I admit to the full the power of soil to purify sewage by oxidation. I admit, moreover, the advantage of intermittency of action, *i.e.*, of intervals of rest alternating with intervals o work. The entire success of the process, however, depends on perfect aëration during rest, to fit the soil for its next period of work. My experiments lead me to doubt the efficiency of a rest of 18 hours only, even when the sewage has had the solids in suspension removed. But of this I am certain, that when the suspended solids have been allowed to remain in the sewage, the glutinous constituents of the sewage, together with the *papier maché* material in solution, clogs the ground with an impervious covering, whereby the entrance of air is very much retarded. Further, the sewage, when applied after the period of rest, cannot flow through the ground on the surface readily, on account of the glutinous layer and *papier maché* film. Thus, as a result, the period of rest fails to become, *quâ* the soil, a period of aëration. This condition will be aggravated should the effluent water, from any circumstance, not flow freely away. Thus the very condition of success may be, and as I know often is, thwarted during the period of rest, as the result of the preceding period of work.

And here I will quote from an excellent paper by Dr. John M. H. Monro, read before the Society of Chemical Industry, and printed in their journal (Jan. 29, 1885). He says:—

> "There are several causes for this disappointing want of success [referring to broad irrigation], but the chief among them is the inability of arable soil to deal with a continuous supply of sewage without great deterioration in its purifying and aerating properties, so that at last it becomes 'sewage-sick,' and inefficient as a purifying agent. This is not completely remedied by intermittent filtration or irrigation, for the land which has been often covered with crude sewage never recovers, even by rest, its original efficacy. The commonly accepted, and I believe the true explanation of this is, that the slimy suspended matter of the sewage gradually chokes the pores of the soil, forming a deposit impervious to air, and thus preventing the aeration essential to nitrification, and, on the other hand, encouraging putrefactive fermentation."

Difficulties of a practical nature crowd upon us in considering this method of treatment. Three, at any rate, may be noted:—

1. The cost of preparing the land for the work.
2. The difficulty of securing proper land, or of ensuring its effective working at all times, in all weathers, with all kinds of sewage, and under all circumstances.
3. The fact that much of the solid filth of the sewage will, unless previously removed, accumulate on the surface, where it undergoes decomposition and becomes, especially in hot weather, a formidable nuisance.

Intermittent downward filtration had its birthplace in the laboratory. Whether the earth used were cube feet or yards, or six foot tubes, many details besides this mere statement of the work accomplished are necessary. Was the earth used surface earth? How was the sewage collected? Was the earth exposed to the modifying influence of wind, light, and and rain? How long was the earth used—a week, a month, a year, or longer? It is to be feared that a new birth in sewage treatment needs a less cramped cradle than a London laboratory. You cannot learn how to direct an army in the field by practising with toy soldiers. No laboratory experiment pure and simple can teach sewage treatment.

We now turn to the hygienic aspect of sewage irrigation. I shall speak of three classes of effects rendering sewage irrigation dangerous to the public health:—

1. Offensive and injurious emanations.
2. Pollution of subsoil water.
3. Distribution of undefæcated sewage containing the ova of entozoa.

I.—OFFENSIVE AND INJURIOUS EMANATIONS.

Of such emanations, the evidence is ample. (Flower on Sewage Disposal, p. 13, *re* Aldershot farm.) The River Pollution Commissioners (1st report, p. 87) admit that odours do arise with land irrigated with sewage, day after day, for years. The Craigentinny meadows, near Edinburgh, can only be described as filthy, emitting a stink hardly endurable. The surgeon to the barrack adjoining the meadows, described the stench (1868) as "sickening." Of the Croydon Sewage Farm, at Beddington, Dr. Creasy, Surgeon to the Orphan Asylum at Beddington, stated that "typhoid fever had been in every cottage on the estate"—every disease, in fact, assuming a particular type, accompanied by what is called "a sewage tongue." In fact the stink of sewage-irrigated ground, and the malarious effects of the sewer gases evolved, are matters of frequent complaint and litigation. Dr. Clouston traced an outbreak of dysentery in the Cumberland and Westmoreland Asylum (where there were 200 patients) to the effluvia from a sewage farm (*Medical Times and Gazette*, June, 1865). The dysentery appeared soon after the sewage was used—31 being attacked, of which 20 cases proved fatal. The farm was 300 yards from the female ward, where the greater number of cases occurred. The sewage farm was removed, and the dysentery disappeared. The following year some land near the asylum was again irrigated, when another outbreak of the disease occurred. The facts show incontrovertibly that sewage emanations may be the cause of dysentery, diarrhœa, and typhoid fever.

The investigations of Letheby into the cause of an outbreak of typhoid at Shaftesbury and the adjacent village of Enmore-green (1862), where one-eighth of the population were attacked in one year (viz., 448 cases in a population of 3,500), clearly point to the morbific effects produced by sewage emanations. We have the same authority pointing to a similar case at Copley village (which lies at the junction of the Hebble Brook and the River Calder), having a population of 1,000, where an outbreak of typhoid occurred from the irrigation of a plot of meadow land with the sewage of Halifax. Dr. Edlin traced, he considers, an outbreak of scarlet fever (23 cases) at Haileybury College, near Hertford, to offensive emanations from a field saturated with sewage, the cases occurring in the dormitories nearest to the garden receiving the urine and slops of the establishment. (Flower on Sewage Disposal, p. 10). Such cases are numerous. I suppose few sanitary facts are so well established as that certain epidemic diseases may be propagated by the excremental pollution of air and water. To keep sewer gas out of our houses, was one of the many great lessons taught us by Murchison. The referees, appointed in 1856, to consider the main drainage of the metropolis, had sound reasons for expressing fear of irrigation on a large scale, lest it should occasion danger to the health of the inhabitants by the pollution of the air of the district—a view, it may be noted, entertained by Liebig, and expressed by him in his well known letter to the Lord Mayor (1865). There is, too, a remarkable statement by Copland, that the effects of sewer gases are never so bad as when emitted from sewage spread out upon the land. This statement is worthy of consideration. Solid matter is given off during evaporation. As the turpentine in lead paint is evaporating, solid lead carbonate is carried into the air, and produces lead poisoning amongst the inmates of the freshly painted house. This cannot result from any volatility of the lead, but merely from the mechanical dislodgement of lead particles during the evaporation of the volatile constituents of the paint. For when the smell has gone, the danger has passed. The sanitarian recognises the importance of defecating the excreta of the typhoid patient as soon as evacuated, and of removing it from the sick room without delay. And why? To prevent the *materies morbi* being carried into the air during the evaporation of the liquid portion. It must, therefore, be an unscientific method to spread the sewage of a mixed population over the land, thereby increasing the area of evaporation. Mr. Hawksley's words may be quoted here. They are the record of one whose unique experience is only rivalled by his acute powers of observation:—"Water irrigation carried on in warm weather is exceedingly unhealthy. I can speak positively to it from repeated observation in different places, that the odour, particularly at night and particularly upon still damp evenings in autumn, is very sickly indeed, and that in all these cases a great deal of disease prevails. The sewage forms a deposit on the surface of the ground, that deposit forms a cake of organic matter, and organic matter when it is in a damp state, as it usually is, gives off in warm weather a most odious stench." (Committee of House of Commons, 1870.)

I am aware that in many cases the sewage before application to the land is submitted to a rough process of filtration; but even in these cases it is no uncommon thing to see masses of partially dried fæcal matter, the remains of previous irrigation, lying about the farm, giving off a filthy stench, and ready to be washed into the nearest stream by the first heavy shower of rain. Such a condition seems peculiar to no soil. Aldershot, with its porous soil (although, strange to say, described by the Rivers Pollution Commissioners as "well managed"), Banbury, with its sandy clay, and Warwick, with its stiff clay, one and all testify to the truth of what I say.

There is yet another point to be considered. That a district saturated with moisture, and more particularly if along with the moisture there is an excess of organic matter (I am excluding specific morbid emanations) is unhealthy and malarious, the fens of Lincolnshire and the rice fields of China, not to speak of other places, supply abundant evidence. Buchanan, in a masterly research, has shown that phthisis is more prevalent where there is a wet atmosphere than where there is a dry one, whilst Pettenkofer, of Munich, regards fever and cholera as dependent on fluctuations in the level of ground water charged with sewage. The case is serious. Saturate—be continually saturating—a large area with sewage water, and as a consequence be continually raising the subsoil water, an increased humidity of atmosphere must result, and conditions favourable to malaria, fever, and phthisis.

Dr. Sturge, in 1879, in a paper before the Institution of Surveyors, gave some important details respecting the sewage of Paris (see also Society of Arts Conference, 1879, p. 151). 70 per cent. of the Parisian houses have cesspools, but even of the remaining 30 per cent., the solid excrement is not allowed to enter the sewers. Some analyses of Paris sewage were given (respecting which, however, I speak with caution) showing 56 grains of organic, and 123 grains of inorganic matter per gallon.

Of the total 60,000,000 gallons daily of Paris sewage, 10,000,000 are treated on 914 acres of land at Gennevilliers. This land has about five inches of alluvial soil resting on ten feet of sand and gravel. I omit all reference to the agricultural success or non-success of the Gennevilliers farm, but it must be noted that authorities consider that the value of building land in the neighbourhood has decreased, and the health of the inhabitants suffered from a rise in the level of the subsoil water. (Report of M. Lefèvre, President of the Société des Géomètres of France.) I quote Dr. Sturge's words (p. 153):—"Great complaints have been made that since the introduction of the irrigation, ague has become far more common than it was before, and more deaths occur from diarrhœa and dysentery."

One thing is abundantly evident, even to any untrained observer, viz., that it is impossible to insure a pure effluent by an irrigation process. The land which is covered with an active crop of vigorous vegetation, is a totally different purifying area from the same land upon which no rye grass or other vegetation is growing. The land under the influence of summer warmth and active evaporation is entirely different from what it is at times of frost or snow. The land flooded with heavy rains is different land from what it is in dry weather. Inequality of purification, uncertainty of action—at one time good, at another doubtful, at another absolutely useless—is the record I have to give from personal observation, and that on no limited scale, of irrigation as a method of purifying sewage. The sewage comes every day to be treated, and no earthly power can say whether your farm is or will be in a condition to deal with it. And more than this—the very condition that increases the quantity of the sewage to be dealt with (such as heavy rain), is the very condition that renders your land temporarily disabled. And yet further still, the very condition that increases the bulk of your sewage, or at any rate its polluting character—the population—is that condition which renders costly the land in the neighbourhood, and probably makes it altogether impossible to procure at any price. I give on p. 1151 certain analyses of sewage effluents from different farms.

II.—POLLUTION OF SUBSOIL WATER, AND OF RUNNING STREAMS.

The select committee on the sewage of towns, although champions of irrigation, admit that if the power of the soil be overtaxed (that is if too much sewage be applied) there must of necessity be injury to wells and running streams.

III.—DISTRIBUTION OF UNDEFECATED SEWAGE CONTAINING THE OVA OF ENTOZOA.

The fact has always been recognised that entozoic diseases have an external origin—*i.e.*, that the ova or parasites come from without, and are not generated within, the human body. Millions of ova are voided with every segment discharged by the person afflicted with tapeworm, each ovum being capable of producing a measle in the flesh of an animal, and each measle a tapeworn in the body of the man.

Here then are two serious consequences of irrigation worth considering:—

I have seen watercresses and celery grown on sewage ground, having a quantity of dried sewage matter deposited on the stems. I have, with more than a cook's patience, tried to wash this matter off, but the tenacity with which it sticks upon the surface of the vegetable when once dry is perfectly astounding. Be it remembered that watercresses and celery are eaten uncooked. I have seen cabbages and turnips, not merely grown on sewage ground, but carefully prepared arrangements made for a weekly flooding with sewage, the market produce being placed in a kind of reservoir permitting sufficient raw sewage to flow into it, so that it may completely cover the vegetation.

The grass covered with sewage, eaten, as it is with rapacity by the cattle, infect their bodies with the larval parasite. Thus the meat is measly, and measly meat, except for efficient cooking, means tapeworm to the human subject. Perhaps a similar story might be told of trichina, with its ten times greater danger. No doubt, as an accident, the danger is constant, but sewage irrigation would practically render it an affair of certainty. In other words, sewage always contains excremental ova. The farm, therefore, that receives sewage must be more liable to produce measly meat than the farm that does not receive it.

"May we not, indeed," says Dr. Cobbold, "but too reasonably conjecture that the wholesale distribution of tapeworm eggs, by the

ANALYSIS OF SAMPLES FROM SEWAGE FARMS.

	Matters in Solution.					Matters in Suspension.		
Constituents per Gallon...	Total Solids.	Ammonia.	Oxygen required to oxidise the organic matter.	Nitrogen as Nitrates.	Chloride of Sodium.	Total Solids.	Organic and loss on incineration.	Mineral.
ALDERSHOT FARM.	Grains.	Grains.	Grains.	Grains.	Grains.	Grains.	Grains.	Grains.
Raw sewage	53·93	7·54	4·38	0	14·92	43·77	29·75	14·02
Effluent	54·12	5·74	3·73	0	19·43	10·17	4·91	5·26
Blackwater stream before receiving effluent	18·93	0·18	0·35	0·26	4·12	2·68	0·69	1·99
Effluent after straining	53·73	7·54	4·40	0	15·36	35·01	26·24	8·77
BANBURY FARM.								
Raw sewage	48·87	3·81	1·42	0	8·94	3·27	1·86	1·41
Effluent	39·73	0·48	0·83	0·63	8·46	0·38	0·13	0·25
WARWICK FARM.								
Raw sewage	47·21	2·20	0·86	0	11·05	24·67	11·87	12·89
Effluent	52·63	0·52	0·48	0·10	9·12	0·26	0·13	0·13
RUGBY FARM.								
1 Raw sewage	36·67	4·43	0·92	0	8·41	1·28	0·64	0·64
Effluent	37·87	1·28	0·42	0·21	7·44	0·32	0·13	0·19
2 Raw sewage	43·40	3·84	0·95	0·22	—	9·52	4·48	5·34
Effluent	36·11	0·48	0·30	0·23	—	—	—	—
WORTHING FARM.								
Raw sewage	30·33	0·23	0·32	0·33	—	4·38	0·87	3·51
Effluent	40·67	0·08	0·12	0·34	—	—	—	—
CARLISLE FARM.								
Raw sewage	30·17	1·92	0·78	0·03	—	3·62	2·17	1·45
Effluent	17·67	0·19	0·27	0·10	—	—	—	—
CROYDON FARM.								
(a) Beddington Raw sewage	27·67	2·00	0·43	0	—	10·16	4·12	6·04
Effluent	27·17	0·12	0·24	0·35	—	0	0	0
(b) Norwood... Raw sewage	41·00	2·00	0·91	0·55	—	11·01	6·03	4·98
Effluent	58·19	0·32	0·82	0·60	—	1·98	0·18	0·80

utilisation of sewage on a stupendous scale, will tend to spread abroad a class of diseases some of which are severely formidable? So convinced am I of the truth embodied in an affirmative reply to this latter query, so certain am I that parasites are propagated in this particular way, so surely do I see unpleasant results if no steps are taken to counteract the evil, that I feel myself bound to speak out boldly, and to produce no uncertain sound in the matter, which most closely concerns humanity. The whole question is, in truth, of vast hygienic importance.''

Let us review our facts. We have dilute sewage to deal with. We desire to be sanitarians, viz., to purify our sewage so that it shall not pollute our watercourses, nor cause nuisance. We desire to be economists, viz., to get out of the sewage all that is valuable in it. In a word, we desire to achieve, by one and the same operation, a sanitary success and a commercial profit. In sewage treatment, as in other things, you cannot combine the impossible. Achieve your commercial success, and you must abandon sanitary considerations. You must, as at Edinburgh, flood your land with your thousands of tons of sewage per acre, until your farm is a stinking morass, and your effluent water so impure that you must take it directly into the sea lest you foul your watercourses. Achieve your sanitary success, sprinkle your 300 tons per acre per annum on your land with hose and jet, and away goes your agricultural profit. Try a compromise between the extremes of the 300 and 10,000, and you get the difficulties of both with the advantages of neither. I admit possible exceptions; a small population; cheap land removed from human habitation; a porous soil admitting free percolation; happy gradients not requiring steam-power; proximity to the sea, so that extreme purity of effluent need not be demanded; proximity to a town, so that a ready sale for the sewage grass for dairy purposes can be secured. But the difficulties are enormous. I must have enough land—and the greater the population with whose sewage I have to deal, the greater the quantity of land required, and the larger probably its price. I must have proper land—sufficiently porous, but not too porous, properly levelled and drained. If the level of my land be above the sewer outfall, I require costly motive power. The larger the quantity of sewage (as in wet weather) with which I have to deal, the less able is the already over-loaded ground to cope with it. Frost or snow, the work has still to be done. At all times the effluent must be sufficiently pure, lest litigants be aroused. At all times the operations must be conducted without offensive smells from an over-sodden state of soil, and without polluting the air by rendering it abnormally damp or polluted by sewage effluvia, the prolific source of typhoid. The subsoil water must be so diverted, that neighbouring wells shall not be polluted. Grant all these difficulties overcome, and there remains as the produce of my farm a grass only fit for dairy purposes, and even then likely to be a source of entozoic infection to man and animals.

DEODORISATION OF SEWAGE.

To get rid of the offensive smell of sewage has been a fruitful subject for investigation. Since the time of Davy, who investigated the deodorising power of different chemicals on night soil, numerous experimenters have worked at it.

The following are the results of Letheby's experiments, showing the quantities of different disinfectants required to deodorise ordinary London sewage. The substances were added until subsequent decomposition was entirely prevented, or more sewage smell removed. Dr. Letheby notes that no doubt a less amount would suffice, provided the precipitate produced by the several chemicals was removed as fast as formed:—

	Grains required per gallon.	Results as to deodorisation.	Composition.
Quicklime	12	Incomplete.	
Chloride of lime	8	Complete.	
McDougall's powder	40	Incomplete.	
Peat charcoal	150	do.	
Condy's liquid	150	Complete.	4,357 grs. per gallon of Permanganate of potash ... sp. gr. 1055
Dale's ,,	313	Incomplete.	64,827 ,, ,, ,, Perchloride of iron ... ,, 1470
Ledoyen's ,,	1000	do.	8,120 ,, ,, ,, Nitrate of lead ... ,, 1160
Ellerman's ,,	470	do.	43,434 ,, ,, ,, Muriate and pyrolignate of iron ... ,, 1443
Burnett's ,,	100	do.	60,031 ,, ,, ,, Chloride of zinc ... ,, 1591

The cost may be thus stated:—

	Price at.				Cost for deodorising 100,000 gallons.		
	£	s.	d.		£	s.	d.
Quicklime	0	10	0	per ton.	0	0	9
Chloride of lime	15	0	0	,,	0	15	4
McDougall's powder	12	0	0	,,	3	1	3
Peat charcoal	3	5	0	,,	3	2	3
Condy's liquid	0	1	0	per gal.	10	14	4
Dale's ,,	0	0	6	,,	11	3	7
Ledoyen's ,,	0	0	4	,,	23	16	4
Ellerman's ,,	0	0	9	,,	25	3	6
Burnett's ,,	0	4	0	,,	28	12	0

STRAINING, FILTRATION, AND SUBSIDENCE.

Many attempts have been made not only to strain and filter sewage, but also to allow the deposition of the larger pieces of the suspended matters in tanks, with or without straining. As a fact, it is impossible to strain sewage efficiently, or to effect deposition without previous treatment. If the straining material be of fine texture, such as of wire, it soon clogs, whilst if it be of coarse texture, it is of no use. If fine gauze, or an iron grate be used, the albuminous matters soon choke it, and prevent further action. In Baldwin Latham's self-cleansing extractor (an ingenious contrivance in use at Dantzic, Croydon, Coventry, &c.), and consisting of a vertical strainer rotating about a horizontal axis, the solid matter being raised from a central receptacle by an Archimedean screw, the most that can be said is that the grosser matters are removed. But even here, a considerable play of water upon the gauze is required to ensure its action.

It was formerly a common practice to strain the sewage through wooden planks perforated with $\frac{3}{4}$-inch apertures, before applying it to land (as at Newcastle-under-Lyme, Southam in Warwickshire, Aldershot), a proceeding that reduced the suspended matters some 9 or 10 per cent.

Of the attempts at filtration, the following cases may be noted :—

(1.) Gravel was used at Abergavenny, Alton, Ashby de la Zouch, Atherton, Cheltenham, Coventry, Ludlow, Oswestry, Saffron Walden, Southam, Tewkesbury, Walton-on-the-Hill.

(2.) Burnt gravel was tried at East Barnet.

(3.) Cocoa matting and gravel strainers were tried at Wellingborough.

(4.) A filter of gorse, with broken stones, was tried at Ulverstone.

(5.) Charcoal, or coke, or ashes, were used at Bacup, Bishop Auckland, Canterbury, Chelmsford, Chesterfield, Croydon, Uxbridge, and Bilston.

(6.) Straw strainers, with ash filter beds, were tried at Bilston and at Canterbury. Straw filters alone were used at Buxton.

(7.) Charcoal and gypsum were tried at Bury St. Edmunds.

(8.) Charcoal and gravel filters were tried at Ealing, Fareham, Harborne, Newcastle-under-Lyme.

(9.) A filter bed consisting of straw, dry earth, ashes, sand, heath, and burnt clay was tried at Hurstpierpoint.

(10.) Peat was tried at Bradford. (1873).

(11.) Sand was tried at Ely, Rugby, and Birmingham.

(12.) An iron slag filter was used at Merthyr Tydvil.

A combined system of subsidence and filtration has been attempted on many occasions. This method was formerly adopted at Birmingham, where the sewage was conveyed through a series of tanks, the passage occupying about two hours. Two sets of tanks were employed, each set being worked continuously for about a fortnight, when the sludge was removed and consolidated by evaporation and soakage in properly prepared pits. The effluent water was found to be offensive, and the works a nuisance. Coventry formerly adopted a similar process, a coarse gravel filter running the whole length of one tank being employed, through which it passed into a second, and again into a third tank of small gravel. The purification proved very inefficient.

At St. Thomas, adjoining Exeter, a similar method of defecation by subsiding tanks, iron strainers, and gravel filters (forming the tank boundaries) was adopted, although in this case a little lime and about 0·75 gallon of carbolic acid to 200,000 gallons of sewage, were added. The carbolic acid proved valuable.

At Uxbridge again, a combined system of subsidence, straining through a grating, and filtration through charcoal, is adopted, before the sewage is discharged into the Colne. It is, however, quite certain that mere subsidence and filtration, as methods of sewage treatment, are failures.

We may here mention the suggestion of Strang, of Glasgow, of treating the sewage discharged from a water-closet, by upward filtration through a box containing the refuse ashes of the house. By this means the solid matter is retained in the lower part of the vessel, and the liquid matter passes through the ashes. Dr. Anderson, of Glasgow, reports well of the apparatus. Mr. Austin, late of the Local Government Board Office, was of opinion that sewage might be dealt with by placing a series of portable filters in the sewers. (Society of Arts Conference, 1877, p. 14.) By this means much of the kitchen stuff could be kept out of the sewers, which, it is true, is often as objectionable as, if not more objectionable than, the sewage itself.

Whatever filtering material you use, be it sand, gravel or charcoal, two difficulties are inevitable :—(1) That the filter soon becomes choked, when it fails to act, or acts inefficiently, (2) that the matters deposited on the surface of the filter, cause an insufferable nuisance. It may be said, as regards the first objection, you have only to recharge your filters and to utilise the old material for manure. The answer is, the cost of material and of labour, and the difficulty of securing a sale for your refuse. To meet the second objection it is said, "Cultivate the surface of your filter beds, whereby vegetation can be made to use up the obnoxious matters." In practice, however, this is not successful, whilst it is impossible to secure a crop all the year round.

I know of no place where filtration alone has proved a success hygienically. Of course intermittent downward filtration is practically land filtration. The objections urged to general filtration, apply equally to land filtration.

Some interesting details respecting the filtration of the foul water of the River Plate is given by Mr. George Higgin ("Proc. Inst. Civil Engineers," vol. lvii.). They show the extreme difficulty of filtering this impure water, a difficulty which is nothing compared to that of filtering sewage.

Discharge of Sewage into the Sea.

Seeing sewage is worth so little, it is no wonder that local authorities have been desirous, where possible, to get rid of it by permitting its discharge into the sea (see Hawksley's Social Science Address 1876, p. 28). This has been done at Weston-Super-Mare, St. Leonards, Torquay, Eastbourne, Llandudno, Dover, Carnarvon, Brighton, Margate, and Ramsgate. There is much to be said in favour of this method. No doubt it appears wasteful, but nature is certain to utilise in due course in her own way what we fail to utilise in ours. But it must be noted that a nuisance is possible if the sewage be discharged into the sea too near land, from the foul matters in suspension being brought back again by the tide to putrefy on the shore during low water. This was said to have occurred at Dover ("Proc. Inst. Civil Engineers," vol. xliii. p. 221) and at Carnarvon. A stink may result, moreover, from the reduction of the sulphates of sea water to sulphides by the organic matter in the sewage, and the evolution of sulphuretted hydrogen by the action of carbonic acid on the sulphides so formed. Possibly to some such cause the smells and unsanitary condition of the Bay of Naples, the Port of Marseilles, the Bay of Cadiz, the West Coast of Africa, and other places owe their origin. This difficulty is worth considering, moreover, more particularly in those cases where a town extends down to the water's edge. No doubt further sewage matters, flocculent materials, corks, &c., have a special tendency to float on sea water, continuous decomposition resulting. Difficulties have arisen at Margate, Ramsgate, and Brighton, from these several causes.

Evils resulting from the discharge of sewage into tidal rivers, containing sea water have occurred at Glasgow and towns adjacent, where the sewage was taken into the Clyde, and were investigated by Sir John Hawkshaw in 1874, who recommended its discharge into the Firth of Clyde at Farland Head. The discharge of sewage into the Thames was also a subject of inquiry by a Royal Commission, and was discussed by Professor Stanley Jevons in a letter to the *Times* of December 2, 1878. I need only point out that the discharge of sewage into a tidal river involves cost for dredging (see Rivers Pollution Commission 2nd report, 1868, p. xiii).

Regarding sewage (which I do) as a thing to be got rid of, and for which we must be prepared to pay to be rid of it, there are manifest advantages in taking it out to sea or estuary. It should, however, in such cases, be discharged in deep water, at a considerable distance from land below the line of low water, and where there is a well ascertained current to carry it permanently seaward. Careful tidal observations are needed before deciding on the point of discharge. A spot where there is an oscillating action resulting in a return of sewage matter either in the neighbourhood of the discharge, or at distant places to which the tide carries it, must be avoided—in other words, we must not allow a turn of the tide to carry one person's refuse to somebody else. It is difficult to imagine a nuisance resulting under carefully considered conditions, more particularly if the discharge pipe be some distance from the town, and the town itself well above the sea level. Still, even in all cases, it is worth considering whether or not some process of clarification may not be advisable.

It is worthy of note, that chloride of magnesium is itself a precipitating agent for sewage. Again, sea water, owing to the common salt present in it, has a tendency to reduce the ease with which organic matter is oxidised. Thus the oxidation of the organic impurity of the sewage is less rapid when it is discharged into salt water, than it is when discharged into fresh.

In the "mud inquiry," the Conservators of the Thames contended that certain sewage banks in the river were caused by the sewage outfalls at Barking and Crossness. In time, these sewage deposits putrefy, rise to the surface, give off offensive gases, ultimately sinking to undergo fresh putrefactive changes. It is certain that in a tidal salt river, foul banks of sewage mud may form, which in ordinary rivers would not be produced. Of course, I admit that a strong tidal current might carry these masses away, but in the absence of such current, they subside and mingle with the sand and mud of the beach.

The Bill of 1875, promoted by the West Kent Main Sewerage Board, was for the purpose of conveying the sewage of Bromley, Beckenham, Hayes, Orpington, Chislehurst, The Crays, Bexley, Crayford, East Wickham, Erith, and Dartford, to Long Reach on the River Thames, eight miles below the outfall of the metropolitan sewage.

PRECIPITATION PROCESSES.

By "chemical precipitation," or "the chemical treatment of sewage," is implied the addition of certain chemicals to the sewage, whereby the deposition of the solid suspended matters and some of the dissolved matter from the formation of insoluble compounds, together with the deodorisation of the offensive constituents precipitated or dissolved, is effected.

The general features of a chemical process for sewage may be thus described :—

To the sewage (from which the grosser suspended matters may or may not be removed) chemicals are added, either suspended in water, or, if soluble, dissolved in water. After this treatment, the sewage is allowed to flow into subsidence tanks, where either it is allowed perfect rest for a few hours or is passed through a series of tanks continuously, in order in either case to allow the deposition of the sludge—that is, of the matters in suspension. The clear effluent is then allowed to flow either directly into a watercourse, or over land previously to its discharge. The black fluid or sludge in the tank (of which 90 per cent. is water) is then all that remains to be dealt with.

The precipitants to be employed have been subject matters of numerous patents. Of these we shall note the most important.

I.—PROCESSES INVOLVING THE USE OF LIME AS THE CHIEF PRECIPITATING AGENT.

Lime.—The use of lime for disinfecting excreta was the subject of a patent in 1802 (Estienne.) In 1844, lime was used to purify the Manchester sewage before discharge into the River Medlock. This was done at the suggestion of Dr. Clark, of Aberdeen, who at that time was at work at his process for softening water by the use of lime, and as the result of which, he was led to suggest its use for sewage precipitation. It was abandoned for a time at Manchester on the ground of cost (a ton of lime being required daily), but was re-adopted in 1854, at the suggestion of Crace Calvert, who advised, after the addition of two or three grains of lime per gallon, complete rest of the liquid so treated in subsidence tanks, his report stating that the precipitate subsides rapidly, the supernatent water being clear, colourless, and inoffensive.

In 1846, Mr. William Higgs took out his patent for the treatment of sewage in subsiding tanks or reservoirs by means of chemical agents. For the purpose of precipitating the solid animal and vegetable matters contained therein, hydrate of lime (commonly termed slack lime) was preferred. In 1851, Mr. Thomas Wicksteed patented a process for manufacturing manure from sewage, &c., by admixture with lime, collecting the deposit and submitting it to certain centrifugal drying machinery, thus obtaining, to use his own words, "the manure as fertilising material in a state commodious for transport."

Action of Lime.—When lime is added to raw sewage, a carbonate of lime is first formed. This acts as a weighting material, whereby, if the opportunity be afforded, the light floccu-

PROPORTIONS OF ORGANIC AND MINERAL MATTERS PRECIPITATED FROM A GALLON OF LONDON SEWAGE WITH 12 GRAINS OF LIME.

Sewage from	Original Sewage.				Precipitated with 12 grains of lime.		Soluble organic matter removed.	Do. do. still in solution.
	Dissolved.		Suspended.					
	Organic.	Mineral.	Organic.	Mineral.	Organic.	Mineral.		
	grains.	grains.	grains.	grains.	grains.	grains.	grains.	grains.
The Fleet Sewer	11·60	30·00	14·40	12·60	17·34	29·71	2·94	8·66
London-bridge do.	20·96	37·09	7·04	15·40	12·46	27·69	5·42	15·54
Dowgate-dock do.	27·31	38·36	16·64	13·26	23·94	26·52	7·30	20·01
Irongate do.	11·20	65·01	15·80	16·32	18·81	29·07	3·01	8·18
Paul's-wharf do.	21·79	51·35	17·21	32·21	23·18	44·69	5·97	15·82
Whitefriars-dock do.	3·53	23·02	9·59	4·89	10·45	16·97	0·86	2·67
Custom-house West do.	9·22	64·30	36·28	42·21	39·02	50·01	2·74	6·48
Custom-house East do.	20·19	37·82	12·13	14·82	17·55	24·97	5·24	14·95
Hambro'-wharf do.	14·24	32·79	4·26	12·75	7·99	25·03	3·73	10·51
Wool-quay do.	10·76	23·84	35·04	46·41	37·85	59·32	2·81	7·95
Average of all	15·08	40·66	17·06	21·09	20·86	33·39	4·20	11·08
	55·74		38·15		54·25			

lent suspended matters will be carried down along with the precipitated carbonate. In addition to this, however, a certain proportion of dissolved organic matter is also precipitated, the lime forming with the organic matter a compound of uncertain chemical composition.

Crace Calvert, operating on the Manchester sewage, gives the following as the average results of five days' treatment by lime:—

	Matters in Solution.			Matters in Suspension.		
	Total solids.	Mineral.	Organic.	Total solids.	Mineral.	Organic.
Raw sewage	32·00	23·46	8·54	6·65	3·08	3·57
Effluent	25·76	22·26	3·50	0	0	0

The action of lime on London sewage was the subject of a prolonged investigation by Dr. Letheby during the time I acted as his assistant. The results obtained by the addition of twelve grains of lime per gallon of sewage are given in the Table on page 1155.

In Calvert's experiments on Manchester sewage the lime effected the entire removal of the suspended matter (mineral and organic), and more than 50 per cent. of the dissolved organic matter. In Letheby's and my own experiments, the removal of all the suspended matter was effected, and about one-fourth of the dissolved organic matter.

The action of lime was further investigated and reported on by Hofmann and Witt, as one of the most promising of the many processes for obtaining a deposit from sewage, which, when dry, might be employed as manure. Operating on London sewage with 20 grains of lime per gallon (800 grains of lime to 40 gallons of sewage), the following results were obtained:—

	Matters in Solution.			Matters in Suspension.		
	Total Solids.	Organic.	Mineral.	Total Solids.	Organic.	Mineral.
Raw sewage....	107·6	52·36	55·24	52·49	36·4	16·09
Effluent........	96·02	40·34	55·68	traces	traces	traces

In other words, 20 grains of lime removed all the suspended matter, and more than one-fourth the dissolved organic matter.

After the addition of the lime, a flocculent precipitate is formed. This settles at the rate of about one-fourth part the bulk of the liquid in one hour. The clear supernatant liquor is colourless, clean, and comparatively odourless. Hygienically, the process is successful—commercially, it is not successful, because the precipitate is mainly carbonate of lime and non-nitrogenous organic matter.

These laboratory experiments are confirmed by practical working. Thus Higgs's process was used at Tottenham in 1857, the results being so satisfactory that the Local Board of Health gave a testimonial certifying to its efficiency (sewage treated 175,000 gallons daily, or sewage of 10,000 persons—12 grains of lime added per gallon (1 ton per week)—dry precipitate obtained was four to five times the weight of the lime used). That the success was no mere accident is proved by the high eulogium passed on the process by Normandy and Miller in the action brought by Higgs against the Hitchin Local Board for an infringement of his patent.

TOTTENHAM.

	Matters in Solution.				Matters in Suspension.		
	Total Solids.	Organic.	Mineral.	Ammonia.	Total Solids.	Organic.	Mineral.
Raw sewage..	54·50	9·49	45·01	2·60	39·99	14·53	25·46
Effluent	48·99	8·01	45·98	2·84	1·69	0·37	1·32

Why, then, was not this hygienic success continued? The reason is obvious — the manure was found to be of so little value that the commercial result proved a failure, Mr. Higgs transferred his expensive works for a merely nominal sum to the local authority, who (in spite of their testimonial showing the capabilities of the process) so neglected them, that shortly after the transference, an injunction was obtained by the trustees of the River Lea, to prevent foul undefecated sewage being discharged from the works. Carelessness and parsimony are certain to ruin the best of processes.

Wicksteed's process was adopted at Leicester in 1855, the works which cost £30,000 to £40,000 being managed in the first instance with marked success. [Sewage treated (1858), 2,000,000 gallons daily, or the sewage of 65,000 person, 3 to 16 grains of lime were added per gallon. Sludge (dry) was 3 to 4 times the weight of the lime used].

LEICESTER.

Constituents per gallon.	Matters in solution. Total solids.	Matters in solution. Organic.	Matters in solution. Mineral.	Matters in solution. Ammonia.	Matters in suspension. Total solids.	Matters in suspension. Organic.	Matters in suspension. Mineral.
Raw sewage.	70·00	13·49	56·51	2·52	19·15	5·50	13·65
Effluent	66·99	10·65	56·34	2·61	1·40	0·49	0·91

Very high was the commendation passed on this process by Aitkin and Taylor, after a minute investigation in 1851. But the Corporation shirked the lime, and neglected the works. No wonder that the River Soar, into which the effluent is discharged, became foul, a result which is certain to be attributed by partisans to failure of the lime process rather than to its true cause, viz., the miserable carelessness and false economy of those to whom the management was entrusted.

The value of the sludge precipitated by lime has been variously estimated as from 15s. 6d. to 29s. 6d. per ton. Voelcker, who fixed 15s. 5d., gives the following as its composition :—

		Value per ton. £
Moisture	10·52	—
Organic matter	12·46	1
Phosphate of lime ..	2·27	7
Mineral matter	54·75	—
	100·00	
Nitrogen	0·60	—
Ammonia	0·72	56

No doubt, as an agricultural article, this manure is worth very little indeed compared to the extravagant views entertained of its fertilising power by the earlier patentees. Local authorities have to learn that to treat sewage means outlay, and that cost is no excuse for neglect.

I conclude by laying down certain essentials for the successful treatment of sewage with lime :—

1. The lime used should be in a perfectly caustic state, and before admixture with the sewage should be thoroughly slaked and mixed with sufficient water to render it the consistency of a thick cream.

2. That the quantity added should not be less than ten grains per gallon, to a sewage that does not exceed thirty gallons per head of the population.

3. That very complete agitation of the lime with the sewage is advisable in order to secure perfect admixture of the lime and flocculation of the precipitate, thus rendering the after subsidence more rapid. This admixture is effected preferably by means of a paddle-wheel mixer, the axis of which is at the water line of the well in which the mixing process is effected.

4. That after precipitation the defecated sewage should flow over an apron into a tank, which should be at least 4 ft. deep, and capable of holding at least one hour's sewage, and from this into a second tank over a weir placed half-an-inch below the surface and at the opposite end to the apron over which the sewage enters, this second tank being capable of holding at least four hours' sewage.

5. Or, if this continuous process be not adopted, the defecated sewage should then be allowed to remain at rest in a tank for at least one hour.

6. That the sludge should be removed in summer time once in 48 hours, and after removal be pressed, or otherwise consolidated and dried with all reasonable speed.

The frequent removal of the sludge is a matter of importance. If this be not done, it putrefies, rises in large flakes, and promotes the decomposition of the supernatent water. It is not difficult by the operation of a dirty tank to undo all the good done by chemical treatment. It will be manifest that a double set of tanks is necessary for successful working.

PLACES WHERE LIME HAS BEEN OR IS BEING USED.

Hertford.—Population about 7,000. Lime was employed from 1858 to 1875, at a cost of £410 per year.

Alton (*Hampshire*). — Population 4,192. (Chloride of iron also used on hot days.)

Balsall Heath (Worcestershire).—Population 14,000. Filtration through gravel. Effluent discharged into Birmingham and Warwick Canal.

Blackburn (*Lancashire*). — Population 83,000. Lime used as an auxiliary to irrigation.

Birkdale.—Population 8,705. Cost £1,000 per annum (= 5d. rate). Sewage treated 650,000 gallons daily. Lime used per year, 208 tons.

Birmingham. — Adopted in 1872 on the recommendation of Mr. Hawksley. Lime is added to the sewage at a distance of one-third of a mile from tanks (13 tons to 12,000,000 gallons). The treated sewage flows into tanks, and the effluent passes into the River Tame. About 400 tons per day of precipitate obtained, which is partially dried and buried. General Scott attempted to make Birmingham sludge into a cement, but not with marked success.

Bromley (Kent). — Population 12,000. Filtration through gravel after lime treament.

Burton - upon - Trent.—Population 20,378. Sewage very foul (about 6,000,000 gallons daily) on account of the brewery refuse, and often of a high temperature. Lime used up to 1883 at the rate of one ton per million gallons. Cost of treatment, £2,000 to £2,500 per annum. Irrigation on 460 acres now adopted.

Bradford (Yorkshire). — Population 173,000. Eight to eight-and-a-half million gallons daily, containing much manufacturing refuse. The sewage is screened, 300 tons of deposit per year being thus obtained. It is then precipitated with lime (1 ton to a gallon), and passed into tanks, where it is allowed a rest of from 30 to 45 minutes. Effluent discharged into Bradford Beck, a tributary of the River Aire. Cost 8d. per head of population. For a short time the sewage was filtered through peat charcoal, by the Peat Engineering and Sewage Filtration Company.

Chester. — Population 35,232. 1,500,000 gallons per diem. Some of the sewage treated with lime, but the most part by irrigation. Effluent discharged into River Dee.

Ealing.—Population 9,959.

Harborne (Staffordshire). — Population 5,105. Lime in conjunction with filtration through gravel, coke, and charcoal.

Leicester.—Sewage dealt with partially and inefficaciously.

Luton.—Sewage contains chemicals used in bleaching and dyeing straw plait.

Lime treatment has also been used at Banbury, Coventry, Cheltenham, Halifax, Hitchin, Leamington, Leytonstone, Leeds, Newcastle - under - Lyme, Ormesby, Over Darwen, Oxton, Southborough, Tottenham, West Ham, and Worksop.

Lime undoubtedly has its objections, foremost of which are:—

1. If the lime be added in sufficient quantity to produce good results (which it can be) the amount of sludge produced is very large and very valueless, consisting principally of non-nitrogenous organic matter and carbonate of lime.

2. The effluent is strongly alkaline, and, therefore, more or less liable to putrefy.

3. Free lime is injurious to fish life. Hence a lime effluent is liable to destroy the fish in a river, unless it be, previously to discharge, treated with an acid.

LIME AND CHLORIDE OF LIME.

At Hertford, in 1866, about 8¼ bushels of lime and 150 lbs. of chloride of lime were used daily in the treatment of 1,640,000 gallons of sewage per day (=lime 2 grains, chloride of lime 0·64 grains per gallon). At this time the population was 7,000, showing the great quantity of subsoil water that must have mixed with the sewage in its transit to the works (= 234 gallons per head). The lime (as cream of lime) added, was apportioned to the rate of flow by little buckets attached to a water-wheel. The treated sewage was now discharged into a depositing tank. The tanks are in duplicate, each tank being worked three days, where it remained about forty minutes, a period too short for complete subsidence. The tank was divided under the water line by a cross wall, the sediment being thus kept back, the supernatant water being then filtered through 6 or 7 inches of coarse gravel and 3 inches of fine sand. The filter required cleansing daily. From the filter beds it passed into an effluent channel about a mile long, to be discharged into the River Lea at Ware Mill. About 12 cwt. of sludge was removed daily. After flowing along the outfall channel for a quarter of a mile, it became clear, fish and vegetation being found in the water in abundance.

In 1866, the following analyses were obtained:—

Date.	Matters in solution.			Matters in suspension.		
	Total solids.	Organic.	Mineral.	Total solids.	Organic.	Mineral.
Raw sewage, Aug. 26	26·95	1·70	22·25	2·45	1·05	1·0
Effluent, ,, ,,	26·00	1·00	25·00	0·85	0·35	0·5
Raw sewage, Aug. 31	29·30	1·95	27·35	6·30	3·25	3·1
Effluent, ,, ,,	27·25	1·20	26·05	1·30	0·60	0·7
Raw sewage, Dec. 13	30·33	5·35	24·98	5·39	0·71	4·68
Effluent, ,, ,,	27·00	2·51	24·49	0·74	0·24	0·50

In 1867, 3·43 grains of lime and 0·33 grains of chloride of lime were used per gallon, and the analysis (November) was as follows :—

	Matters in Solution.				Matters in Suspension.		
	Total Solids.	Organic.	Ammonia.	Oxygen to Oxidise.	Total.	Organic.	Mineral.
Raw sewage	25·0	2·50	0·34	·296	1·42	0·72	0·70
Effluent	28·33	1·25	0·45	·281	0·43	0·17	0·26

The chloride of lime, although only one-third of a grain per gallon, not only disinfected the sewage, but prevented the growth of the sewage fungus.

My experience enables me to speak favourably of the employment of chloride of lime with lime, especially in hot weather. About 56 lbs. per 1,000,000 gallons will be found, as a rule, fully sufficient for a sewage represented by thirty gallons per head of the population.

Lime and Sulphate of Soda.

Fulda's Process.—This process was tried on a small scale at Pratt's cloth mills (Yeadon, near Leeds), and at Barnsley Union Workhouse in 1873. The process was abandoned, the effluent not proving satisfactory.

Salts of Magnesium with Tar and Lime.

Fritz Hillé's Process.—The process of Fritz Hillé (patented 1870) was to be used as follows :—A mixture of lime (100 lbs.), gas tar (3 lbs.), chemical salts, viz., chloride of magnesium (17 lbs.), were made into a paste with 180 lbs. of water. Hillé, however, does not bind himself to these exact quantities, varying them according to the composition, strength, and quality of the sewage to be treated. From the decomposition of the magnesium chloride by the lime, a bulky precipitate is formed, which carries down the suspended matter.

The exact quantity of paste to be added must also be a matter of experiment. It will vary from ¼ lb. to 1 lb. per 100 gallons, or from 10,000 lbs. (= 4 tons, 9 cwt., 1 qr., 4 lbs.) to 2,500 lbs. (= 1 ton, 2 cwt., 1 qr., 8 lbs.) per million gallons. This quantity, however, supposes subsequent filtration.

Hillé suggests that the sludge may be advantageously used again as a precipitant for fresh sewage, employing for this purpose a mixture of from two to five parts of sludge with one part of the paste. Further, he considers that depositing tanks are not essential, but that the sewage after treatment may with advantage be applied directly to the land.

If tanks be employed, they should not be used for more than three days at a time. (See paper by Hillé, Society of Arts Conference, 1879, p. 139. See also Hillé's pamphlet on "Sewage Disinfecting, with Analyses by Letheby," pp. 13 to 15).

The following are places where Hillé's process is or has been employed :—

Edmonton.—Still in use. Population 15,000. Daily sewage 800,000 (domestic and dilute). The materials are added in the proportion of 3 tons 7 cwt., at a cost of £6 per 1,000,000 gallons (= 1s. 2d. per head per annum). The sludge formed is stated to be three tons daily. There are 114 acres of land used for subsequent irrigation with the effluent.

Tottenham.—(Population 23,000; sewage 1,200,000 gallons daily.) The cost of maintaining the works in 1875 was £1,979.

Windsor, Aldershot, Leicester, Grantham, and *Taunton* have also used the Hillé process.

At *Wimbledon*, Surrey, (population 12,500), the process was employed from 1870 to 1876.

SALTS OF ALUMINA.

Numberless patents have been taken out for treating sewage by means of compounds of alumina.

If sulphate of alumina only be used, the ammonia of the sewage would in time effect its decomposition, resulting in the precipitation of alumina. The action of alumina thus set free is to combine with the soluble organic matter, with which it forms an insoluble compound. Thus it is used as a mordant or fixing agent for colours when applied to fabrics, and to precipitate colouring matters from their solutions, forming insoluble compounds called "lakes." Ammonia and phosphoric acid are also fixed by aluminous compounds.

Stothert (1852) patented a mixture of sulphate of alumina (or sulphate of zinc), caustic lime and charcoal (obtained from sewage or night soil) as a precipitant for sewage. The quantities suggested were 73·5 grains respectively of sulphate of alumina and charcoal, 3·5 grains of sulphate of zinc, and 22 grains of slacked lime per gallon. The lime was to be added first, and then the mixture of charcoal with sulphate of alumina. Hofmann and Witt report (1857) the following results produced with 5 ozs. of lime and 10 ozs. of the alumina mixture to 40 gallons of London sewage:—

	Matters in Solution.			Matters in Suspension.		
	Total Solids.	Organic.	Mineral.	Total Solids.	Organic.	Mineral.
Raw sewage	107·6	52·36	55·24	52·49	36·4	16·09
Effluent	87·73	37·56	50·17	none.	—	—

They record that the addition of the alumina caused a marked increase of suspended matter, as well as a largely increased flocculation and rapidity of subsidence.

Stothert claims that a ton of the materials, costing 30s., will make two tons of manure worth £2 2s. per ton, containing, when dried, 1·44 per cent. of ammonia, 8·6 per cent. of phosphate of lime, and 34 per cent. of organic matter.

I do not know of this process having been employed on a large scale.

Lenk's deodorising liquid (patent, 1865), was a solution of alum cake (crude sulphate of alumina) containing 12 per cent. of alumina. In the case of London sewage, 25 grs. by weight of the solution sufficed to defecate a gallon efficiently, a very flocculent precipitate forming, which required about 30 minutes to subside.

This process was tried at Tottenham in 1858 for about one week, one ton of solution (value £6 10s.) being used to treat 4,900,000 gallons (700,000 daily). The following results were obtained:—

	Matters in Solution.				Matters in Suspension.		
	Total Solids.	Ammonia.	Organic.	Phosphoric acid.	Total Solids.	Organic.	Mineral.
Raw sewage	91·10	9·76	42·30	3·77	367·7	225·6	142·1
Effluent	63·39	4·23	9·70	trace.	3·01	0·77	2·24

The precipitation was very successful. Voelcker reported that "the effluent might be poured into any watercourse without causing a nuisance." He valued the dry deposit at from 25s. to 30s. per ton.

A curious history is here presented of a local authority, guardians of the public health, and moreover, under an injunction not to pollute the Lea, trying a process for one week, which they admitted gave "fair results," and which others know to have been more than fair, and then abandoning it, whether from carelessness or parsimony I do not know.

Manning (1853) suggested as a sewage precipitant, a mixture of animal charcoal, alum, carbonate of soda, and gypsum, some caustic lime in addition being also advised. The use of alum, on account of its expense, was afterwards dispensed with (patent, 1854), by the employment of a waste obtained in the course of the alum manufacture from the rough liquors (called soft sludge, consisting of sulphates of iron and alumina), and, afterwards (patent, 1855) by the use of various aluminous minerals and earths (alum slate, &c.), treated much in the same way as that adopted in the preparation of alum.

The sewage was to be treated as follows:—The aluminous preparation was to be added to the sewage, and the whole agitated, the un-slacked lime with animal charcoal being introduced during the mixing. The treated sewage was then to be allowed to subside in proper tanks.

This process was favourably spoken of by Penny, of Glasgow, who gives the two following analyses of the sludge:—

	Per cent.		Per cent.
Ammonia	2·22	..	0·884
Phosphate of lime	2·05	..	13·57
Organic matter ..	43·72	..	31·74

The former he regards as of the estimated value of £1 16s. 5½d., and the latter of £1 15s. per ton.

Compounds of Iron and Alumina (Sulphated Clay).

Bird's Process.—Six cwt. of powdered clay is treated with 120 lbs. of sulphuric acid, and the mixture allowed to stand for a week.

The following are places where the process has been used:—

Stroud (Gloucestershire).—This solution of sulphate of alumina and iron is used in quantity equal to 28 to 37 grs. of mixed sulphates per gallon, at Stroud (population 8,000) in Gloucestershire, to defecate 200,000 gallons of sewage. The treated sewage is allowed to run into settling tanks passing from one to another through straw filters, and finally filtered through coke filters. The sludge is dried, and made into a manure by admixture with sulphate of ammonia and phosphate of lime.

The Stroud sewage was examined and reported on by the Rivers Pollution Commissioners in 1868, when a solution containing 6 cwt. of pulverised clay acted on by 120 lbs. of sulphuric acid was added to 200,000 gallons of sewage. They record the effluent as inodorous, but not of a high degree of purity. (See 1st Report, 1868, p. 58.)

Cheltenham.—Bird's process was adopted at Cheltenham in 1868. It was said not to be a success.

Northampton. — In 1872, Northampton sewage, which was then 1,000,000 gallons a day, was defecated with crude sulphate of alumina and iron, made by the action of sulphuric acid on a ferruginous clay. Three cwt. of chamber sulphuric acid were added to 2 tons of clay in a wooden trough, and allowed to remain in contact for a week. The solution was generally found to contain about 15 cwt. of a sulphated ferruginous compound. There were six of these troughs in use—the entire soluble contents of one trough being used daily. The flocculation was imperfect from the want of an efficient stirring apparatus. Moreover, the acid of the chemicals caused effervescence with the carbonates present, a scum being formed from the rise of the suspended matters. This, however, was kept back in the first tank by cross-bars. The sewage then flowed into a second tank, and finally over a weir into a channel a mile in length, when it was discharged into the river. The river itself was clean, the aquatic vegetation healthy, and fish abundant.

The samples given below are averages of many samples taken over 24 hours. The effluents generally were clear and inoffensive.

	Matters in Solution.							Matters in Suspension.				
	Total Solids.		Oxygen required to oxidise.		Ammonia.		Total Solids.		Organic.		Mineral.
Raw sewage	73·60	..	2·265	..	4·98	..	13·83	..	8·48	..	5·37
Effluent, 1st tank ..	70·16	..	1·980	..	4·19	..	4·97	..	2·91	..	2·06
Effluent, 2nd tank..	70·65	..	1·243	..	3·247	..	1·74	..	1·11	..	0·63

About 400 tons of sludge were removed per week. This was mixed with sifted ashes (48 tons) and burnt refuse (20 tons), and found a market at 3s. per ton.

In 1875, the proprietors of Bird's process brought an action against the proprietors of the Coventry process for infringement, in which they were unsuccessful.

A process (*Cobley's* patent) similar to the one just described (the precipitants being said to consist of iron, alumina and carbon) is in use at Crewkerne, the precipitant being placed in a box with perforated sides, the sewage being allowed to flow through the box by which contact with the precipitant was secured. There is no stirrer, but sufficient mixing is said to be effected by the means described. The patentee states that the precipitant can be supplied (exclusive of a small royalty) at £2 per ton. A good effluent, which does not undergo putrefactive change by keeping, is stated to be produced.

At Hertford (population 9,000) the sewage is treated with a solution of sulphate of iron (1 part), lime (2 parts), and sulphate of alumina (2½ parts). It flows into subsidence tanks (7 in all, 5 being used continuously), and finally through a coke filter.

LIME AND SALTS OF ALUMINA (COVENTRY PROCESS).

Anderson, of Coventry, suggested the use of lime and an aluminous compound, prepared by adding 1 part of common sulphuric acid, mixed with its own bulk of water, to 2 parts of clay (shale having also been used). The mixture is to be set aside in a warm place until it appears white on the surface.

One pound of this mixture is to be well agitated with 100 gallons of sewage, and a ¼ lb. of lime (as cream of lime) afterwards added. He advises that the defecated sewage be allowed absolute rest for twenty-four hours, the clear effluent being then drawn off, and the sludge removed.

Odling gives the following results by this process:—

	Matters in Solution.			Matters in Suspension.		
	Total Solids.	Organic matter.	Ammonia.	Total Solids.	Organic.	Mineral.
Raw sewage	42·77	8·33	0·77	89·74	51·66	38·08
Effluent	56·28	6·30	0·84	1·61	0·91	0·70

Both Odling and Voelcker reported highly of this effluent, as thoroughly deprived of noxious qualities.

The sludge is valued by Voelcker at 30s. a ton. He gives the following analyses:—

Moisture	12·01	15·70
Organic matter........	26·89	31·86
Phosphate of lime	2·60	2·55
Mineral salt	6 61	10·33
Silica, &c.	51·89	39·56
	100·00	100·00
Ammonia .... =	1·39	1·22

At Coventry the use of this process was commenced in 1874. It has been ably supervised for many years by Mr. Melliss, C.E. There are, at the present time, four precipitating tanks worked on the continuous principle. The effluent flows through filter beds occupying 9 acres, used intermittently, and is ultimately discharged into the River Sherbourne.

The sewage of Coventry is about 2,000,000 gallons daily, very foul, and much coloured with dye refuse, &c. It needs far more chemicals than average sewage. The sludge produced is about 25 tons per day (90 per cent. moisture). About 2 tons of crude sulphate of alumina (but of which 2-5ths, being insoluble in water, is not put into the sewage), and 10 cwt. of lime are used daily. The cost for chemicals is said to be £1 14s. per 1,000,000 gallons, and the entire cost (including rent, capital on works, management, &c.) about £4 14s. per 1,000,000 (= 1·8½ per head).

Formerly, one portion of the sludge was got rid of in a semi-dry condition at 7s. per ton, whilst another portion, dried and reduced to a portable condition, fetched £2 per ton. Some of the sludge was also "fortified" by added chemicals, and fetched from £5 to £6 per ton.

A similar process was also in use at Nuneaton from 1872 to 1876, when the arrangements between the Local Board and the General Sewage and Manure Company fell through, from some misunderstanding respecting the average daily flow. Nuneaton sewage is offensive owing to the presence of manufacturing refuse. From 400,000 to 500,000 gallons were treated daily. The effluent was filtered through 2 acres of land. The yield of manure was about 1 ton daily. The cost was as nearly as possible the same as at Coventry.

THE A B C PROCESS.—THE NATIVE GUANO COMPANY.

The patent of the Messrs. Sillars and Wigner (1868) claim the use of alum, blood, and clay (hence termed the A B C process), with other agents, viz., compounds of manganese and magnesium, chloride of sodium, animal and vegetable charcoal, with the object—

(1.) Of deodorising and purifying sewage by means of these chemical substances, and so obtaining a sediment which may be used as manure.

(2.) The deodorising and purifying sewage by means of the mud already precipitated from sewage as above described.

(3.) The addition of an acid to the mud in order to retain ammonia, and so fit it for use as a manure.

The precise composition of the precipitating material has been changed from time to time.

When first used at Leicester, in 1868, the precipitating mixture consisted of—

	Parts.
Alum	600
Blood	1
Clay	1,900
Magnesia	5
Manganate of potash	10
Burnt clay	25
Chloride of sodium	10
Animal charcoal	15
Vegetable charcoal	20
Magnesian limestone	2

These were mixed with water, and added to the sewage, until no further precipitate resulted. About 4 lbs. of the mixture were required to every 1,000 gallons of sewage (= 28 grs. per gallon). The treated sewage then flowed into subsidence tanks, where the sediment was allowed to deposit. This sediment was used five or six times over as a precipitant, until its power in this respect was exhausted. After the sludge had been dried, a small quantity of acid (preferably sulphuric acid) was added to fix the ammonia, in which state it was claimed to be a valuable manure.

In 1869, the process was worked at Leamington, the composition of the precipitating mixture being—

	Parts.
Alum	259
Clay	896
Charcoal	56
Clay blood	40
Carbonates of soda and potash	6
Previous precipitate	14
Perchloride of iron solution	1 pint

This mixture was added in the proportion of about 51 grs. per gallon, at a cost of £15 18s. per million gallons of sewage.

The mixture used at Leamington in 1870 was as follows:—

	Parts.
Ammonia alum	336
Clay	672
Animal charcoal	15
Vegetable charcoal	20
Sulphate of magnesium	20
Clay blood	4

Of this composition 56 grains per gallon was found to be necessary.

In 1873, the process was used for a short time at Crossness for the treatment of 500,000 gallons daily of the sewage at the Southern Metropolitan Outfall. The mixture used had the following composition:—

	Parts.
Sulphate of alumina	5
Charcoal	29
Clay	26
Mixed with a little blood.	

This was added in the proportion of 224 grains per gallon, and yielded 12·33 tons of manure per million gallons of sewage (5·25 tons from sewage, and 7·08 tons from the added chemicals), the ingredients costing £24 9s. 8d.

Tottenham, Hastings, Bolton (1872), Southampton, and Leeds afterwards adopted the process, but in all it was abandoned on the ground of cost. At Southampton a contract to deal with the sewage was cancelled after £10,000 had been spent on works, owing to some erroneous expectations respecting profits.

At Bolton, 1872-1873, the chemicals used were as follows:—

	Parts.
Sulphate of alumina	71
Clay	132
Carbon (waste from prussiate of potash factory)	81
Blood, small quantity.	

This mixture was added at the rate of about 90 grains per gallon. The quantity of sewage treated was 2,500,000 gallons daily. The process was abandoned on the ground of expense.

At Leeds in 1870 (sewage 9,000,000 gallons daily, of which the A B C Company were to deal with 2,000,000) the precipitating mixture employed was:—

	Parts.
Alum	5,964
Carbon (refuse from prussiate of potash factory)	4,480
Clay	7,460
Blood mixture	56
Lime	186

About 120 grains per gallon of this mixture was employed. The cost for chemicals per million gallons was £7 5s. The company abandoned the works on June 1st, 1873. In June, 1875, however, they again treated the Leeds sewage for one week with the following precipitating mixture:—

	Parts.
Lime	15,990
Animal carbon	13,556
Alum	8,076
Clay	16,848
Carbolic acid	28

About forty grains of this mixture was used per gallon of sewage, at a cost of £2 8s. 10d. per 1,000,000 gallons.

Another trial was made for one week in

January, 1876, when the cost of chemicals was found to be £3 5s. 9d. per million gallons.

The process, as carried out at Leamington (population 20,000, sewage 600,000 gallons daily in dry weather), was successful. The A B C mixture was stirred into the sewage in a circular tank, from which it passed into two settling tanks, each set being used for one week, there being three sets of tanks for alternate working. The effluent then flowed into a channel 850 feet in length, 10 feet wide, 4 feet deep, the last third of which was converted into a filter of sand and animal charcoal, having a superficial area of 3,000 square feet. The sludge was converted into paste by centrifugal machines, revolving 1,500 times per minute, and afterwards further dried by exposure to air. It was then sprinkled with dilute sulphuric acid (1 of acid to 6 water), the acid being used in the proportion of one per cent. of the manure. It was afterwards heaped for a fortnight, during which time it heated considerably, forming a rotten compost, which was further dried and sold for manure.

About 28 grains per gallon of the A B C mixture was employed, whilst the dried precipitate, containing 20 per cent. of moisture, weighed about 80 grains. Analyses of the effluent at Leamington, as reported on by Dr. Letheby, are as follows :—

Date, &c.		Dissolved matters per gallon.						Suspended ditto.	
		Total.	Chloride Sodium.	Organic matter.	Ammonia.		Oxygen required.	Total.	Organic.
					Free	from Organic Matter.			
		grains.	grains.	grains.	grains.	grains.	grains.	grains.	grains.
Dec. 11, 1869	Raw sewage..	66·13	11·04	14·43	2·543	0·220	1·830	113·60	39·92
	Effluent water.	67·27	9·68	11·27	1·892	0·109	0·951	7·64	2·86
	Ditto filtered..	60·97	7·21	7·50	0·954	0·093	0·488	3·08	1·12
Jan. 29, 1870	Raw sewage..	67·81	14·64	11·09	3·769	0·200	1·804	43·44	14·72
	Effluent water.	51·33	6·01	7·61	0·315	0·060	0·406	1·04	0·30
April 20	Raw sewage..	94·10	18·76	19·25	3·200	0·352	2·400	50·14	29·06
	Effluent water.	72·27	12·52	13·70	3·840	0·200	1·600	2·26	1·12
July 14	Effluent water.	72·33	9·20	6·15	2·520	0·114	0·252	0·60	0·12
Sept. 20	Raw sewage..	86·67	16·52	17·30	4·125	0·711	3·512	34·64	22·12
	Effluent water.	74·93	11·57	13·10	3·467	0·150	1·023	1·54	0·52
Sept. 21	Raw sewage..	81·10	15·58	15·70	5·120	0·440	3·159	29·50	18·14
	Effluent water.	69·30	8·03	8·70	0·690	0·060	0·320	0·16	0·10
Sept. 30	Raw sewage..	95·67	18·17	19·50	10·160	0·320	2·708	7·84	5·64
	Effluent water.	69·67	8·26	7·40	0·971	0·008	0·204	0·00	0·00
Average	Raw sewage..	81·91	15·79	16·21	4·819	0·374	2·569	46·53	21·40
	Effluent water.	67·26	8·97	9·17	1·822	0·098	0·613	1·24	0·76

It will be noted in these analyses that the chloride of sodium in the effluent is less than that of the original sewage. This may be partly explained by its dilution with subsoil water, and also by the fact shown by Voelcker and Way that marly soils possess the power of removing alkaline chlorides from their solutions. (See "Journal of Royal Agricultural Society," Vol. xi. and xviii.).

At Hastings the works were situate on the seashore. The A B C material was agitated by a machine mixer with the sewage, and after flowing through subsiding tanks, was discharged into the sea.

The A B C process depends in great measure on the alumina as a precipitating agent. It is doubtful whether the blood is of any service, as it can scarcely be urged that in the quantity in which it is added, the fibrin can be of much value as an agent for entangling suspended matter. The clay is mainly a weighting agent, to assist the rapid subsidence of the suspended impurities.

Of course the quality of the manure must depend on the quality of the sewage. Hence, as we should expect, its composition is not absolutely constant. Against the valuations of authorities we have the indisputable fact that it is being sold continuously for about £3 10s. per ton.

In the following report, numerous details relating to this process are discussed at length:—

REPORT OF DR. C. MEYMOTT TIDY, M.B., &c., AND PROFESSOR JAMES DEWAR, F.R.S., &c., ON THE A B C SEWAGE PROCESS.

To the Directors of the Native Guano Company.

GENTLEMEN,—The experiments recently carried out by us at Aylesbury for the purpose of determining the conditions and efficiency of the A B C process in the treatment of sewage being now complete, we transmit to you an abstract of the inquiry.

For this purpose you directed that the works were to be at our disposal, the process being continuously and uniformly worked under Mr. Page's management.

The following results therefore really represent the every day working and the practical efficiency of the process.

For here we must remark that isolated observations on the composition of a sewage and of an effluent have no real value in testing the efficiency of a sewage process.

Considering the fact that the strength and composition of the sewage changes so rapidly and frequently [as will be seen from the accompanying Tables, pp. 1166-7-8], it is manifest that conclusions deduced from a few observations are worthless and often misleading. Further, samples of effluent and of raw sewage collected at the same time have, as a rule, no definite relationship to each other, the passage of the sewage through the tanks occupying some hours.

For these and other reasons it appeared to us that to arrive at a satisfactory conclusion on the A B C, or upon any other process, systematic and continuous experimental observations were needed; and further, that in order to obtain a fair average of the daily sewage delivered at the Aylesbury Works, each series of experiments must be continued for twenty-four consecutive hours at least, so as to embrace the varying conditions of the sewage. Samples of the raw sewage and of the effluent were therefore collected by us every half-hour, equal portions of four consecutive half-hour samples being mixed together for chemical examination. The results obtained are tabulated, and represent the mean condition of the sewage and effluent during each consecutive two hours.

It was our special aim to select such dates for the collection of these twenty-four hour samples as would be likely to result in very different conditions of the average sewage. In this we were especially guided by the rainfall, and other local conditions. We were fortunate in getting three series, differing considerably in the total quantity as well as in the strength of the raw sewage to be dealt with.

The next question we considered was the amount of sludge deposited from a given quantity of sewage, and of this sludge the proportions severally of the A B C precipitating materials and of sewage matter. A special arrangement was needed for this purpose, it being found impossible to determine these details with even an approach to accuracy in the large subsiding reservoirs. Four iron tanks, each holding about 200 gallons, were therefore divided, by chalk lines on the inside, into six equal divisions, one of these divisions being filled every hour, by means of a small force-pump placed in the narrow channel down which the treated sewage runs before entering No. 1 tank, with the sewage that had been already treated. The deposit in each of these four tanks, therefore, represented the mean amount of sludge produced during six consecutive hours. The sewage deposit in these tanks was allowed to settle, and the clear effluent syphoned off. The deposited sludge was then dried at 212° F., and weighed. The quantity of carbon clay and alum used during the twenty-four hours was determined, and substracted from the total (calculated) sludge.

Before considering the three series of experiments conducted by us, it may be advisable to give a brief description of the usual method of working the A B C process, and which in our experiments was carried out without innovation of any kind.

The sewage is delivered at the works, through an oval pipe about 2 feet in the longest diameter, into a small oblong space about 4 feet wide by 6 feet long, paved with bricks. Across this space, and about one yard from the sewer mouth, a wooden V-shaped trough is placed, into which the B C mixture is run —even distribution into the sewage being effected by means of numerous notches cut on the sides of the trough. By this means the sewage is completely and immediately deodorised, no escape of offensive odours from the sewage into the surrounding air taking place. The entire works are, in our experience, free from any objectionable smell whatsoever.

After being mixed with the B C mixture, the sewage passes through an iron grid for the purpose of catching paper, straw, and similar floating materials. It then passes along a brick-paved channel for about 12 feet, the channel afterwards narrowing to 2 feet in width. Here the alum solution flows in from a wooden trough in the same manner as we have described in the case of the B C mixture. The alum, it will be noted, is added some short time after the B C mixture. The addition of the precipitating ingredients separately, we are informed, is found to afford better results than when they are run in together.

The treated sewage flows along the 2 foot channel for about 40 yards, in order to facilitate mixture before it is allowed to run into the first subsiding tank. There are three subsiding tanks, each holding 42,000 gallons, through which the treated sewage successively flows before finally passing through a fourth and last tank, which is about double the size of the other three. On leaving the tanks the effluent, now practically free from suspended matter (as will be seen from the Tables) is devoid of smell, passes for several hundred yards along an open brick channel, before finally discharging itself into the brook.

NO. 1 SERIES.

SEWAGE WORKS, AYLESBURY.

Table showing Results of Analyses of Samples of Sewage and Effluent taken at intervals of half-an-hour from 8 a.m. January 29th to 7.30 a.m. January 30th, 1885. For the purposes of Analysis, equal portions of four consecutive half-hour Samples were mixed together.

Number of Sample.	Time.	Flow of Sewage.	Specific Gravity.	Grains per Gallon.								
				Oxygen absorbed from Permanganate.	Ammoniacal Nitrogen.	Chlorine.	Total Suspended Matter.	Organic.	Inorganic.	Total matter in Solution.	Organic.	Inorganic.
	Jan. 29th, 1885.	Gallons.										
1 Sewage	8 to 10 a.m.	53,916	1·003	1·190	·342	3·22	11·480	6·216	5·264	35·84	16·436	19·404
2 Effluent			1·001	·658	1·169	6·09	1·218	·630	·588	68·11	18·13	49·98
3 Sewage	10 to 12 a.m.	46,764	1·002	1·663	1·512	4·90	14·42	8·96	5·46	48·034	15·57	32·45
4 Effluent			1·0045	·616	·973	5·67	·350	·07	·28	61·04	18·48	42·56
5 Sewage	12 to 2 p.m.	47,436	1·0045	2·572	3·560	5·74	19·32	13·58	5·74	48·86	18·06	30·80
6 Effluent			1·005	·546	1·169	5·04	·168	·028	·140	58·45	13·72	44·73
7 Sewage	2 to 4 p.m.	46,404	1·004	3·574	3·458	6·79	46·20	28·00	18·20	49·52	22·05	27·47
8 Effluent			1·004	·476	·682	4·83	·980	·68	·29	52·08	14·84	37·24
9 Sewage	4 to 6 p.m.	48,396	1·004	4·585	3·367	8·19	61·950	26·53	35·42	54·684	20·209	34·475
10 Effluent			1·001	·518	·943	5·00	2·24	1·94	·29	53·90	19·11	34·79
11 Sewage	6 to 8 p.m.	67,368	1·003	1·995	·973	4·27	18·20	6·426	11·774	37·884	14·525	23·359
12 Effluent			1·002	·[illegible]62	1·652	5·32	2·240	1·806	·434	57·575	21·875	35·700
13 Sewage	8 to 10 p.m.	46,404	1·004	1·155	·878	4·13	4·62	2·38	2·24	41·209	14·35	26·854
14 Effluent			1·004	·595	1·757	5·67	2·38	2·226	·154	58·709	16·100	42·609
15 Sewage	10 to 12 p.m.	38,040	1·003	1·190	·922	4·88	18·20	15·106	3·094	39·55	16·191	23·359
16 Effluent			1·001	·574	1·554	5·67	2·24	1·946	·294	54·25	19·25	35·0
	Jan. 30th, 1885.											
17 Sewage	12 to 2 a.m.	38,040	1·0035	·819	·585	3·71	5·74	2·926	2·814	34·825	14·00	20·825
18 Effluent			1·004	·515	1·799	5·25	2·38	2·226	·154	52·325	17·50	34·825
19 Sewage	2 to 4 a.m.	25,332	1·003	·735	·292	4·55	3·36	1·666	1·694	48·737	14·353	34·384
20 Effluent			1·002	·455	1·652	5·11	2·59	2·436	·154	58·100	23·275	34·825
21 Sewage	4 to 6 a.m.	23,868	1·003	·595	·342	4·27	3·220	1·386	1·834	54·95	28·70	26·25
22 Effluent			1·002	·399	1·211	4·83	3·01	2·716	·204	62·30	23·45	38·85
23 Sewage	6 to 8 a.m.	10,116	1·003	1·470	·237	4·62	18·900	9·786	9·114	61·159	24·50	36·659
24 Effluent			1·0025	·357	1·071	4·69	3·290	2·996	·294	53·634	15·75	37·884
Sewage	Averages.	492,084	1·0033	1·795	1·372	4·94	18·80	10·246	8·554	46·271	18·216	28·025
Effluent		TOTAL FLOW.	1·0027	0·522	1·305	5·26	1·92	1·64	0·28	57·54	18·46	39·08

Observations taken at 12 noon January 29th, 1885:—Barometer, 29·2; maximum temperature, 68° F.; minimum temperature, 42° F.; rainfall, 0·125 in.

NO. 2 SERIES.

SEWAGE WORKS, AYLESBURY.

Table showing Results of Analyses of Samples of Sewage and Effluent taken at intervals of half-an-hour from 8.30 *a.m. March 2nd, to* 8 *a.m. March 3rd,* 1885. *For the purposes of Analysis, equal portions of four consecutive half-hour samples were mixed together.*

Number of Sample.	Time.	Flow of Sewage.	Grains Per Gallon.				Ratio between Distillate and Residue.	Grains per Gallon.				
			Oxygen absorbed by									
			Unfiltered.	Filtered.	Distillate.	Residue of Distillate.		Chlorine.	Ammoniacal Nitrogen.	Total Suspended Matter.	Organic.	Inorganic.
	March 2nd, 1885.	Gallons.										
1 Sewage	8.30 to 10.30 a.m.	34,335	1·56	·630	·052	·620	1 to 11·923	4·48	·21	24·2	16·08	8·12
2 Effluent			·756		·157	·756	1 ,, 4·815	6·86	1·25			
3 Sewage	10.30 a.m. to 12.30 p.m	49,747	3·34	1·54	·25	1·53	1 ,, 6·12	6·37	2·08	30·52	20·3	10·22
4 Effluent			·56		·105	·56	1 ,, 5·3	6·02	1·20			
5 Sewage	12.30 to 2.30 p.m.	65,430	5·74	2·80	·42	2·24	1 ,, 5·3	7·56	3·89	98·8	57·0	41·8
6 Effluent			·43		·059	·399	1 ,, 6·762	5·53	·27			
7 Sewage	2.30 to 4.30 p.m.	55,050	3·01	2·296	·325	2·205	1 ,, 6·784	6·93	2·52	18·34	13·02	5·32
8 Effluent			·43		·056	·399	1 ,, 7·125	5·60	·54			
9 Sewage	4.30 to 6.30 p.m.	56,775	4·676	2·408	·308	2·464	1 ,, 8	6·86	2·19	30·8	20·16	10·64
10 Effluent			·518		·098	·441	1 ,, 4·5	5·95	1·20			
11 Sewage	6.30 to 8.30 p.m.	52,384	2·492	1·652	·231	1·967	1 ,, 8·515	5·53	1·31	20·44	16·94	3·50
12 Effluent			·616		·094	·623	1 ,, 6·627	6·09	2·08	1·89*	1·26	·63
13 Sewage	8.30 to 10.30 p.m.	39,806	1·876	1·274	·224	1·218	1 ,, 5·437	6·30	1·25	16·10	12·6	3·5
14 Effluent			·672		·115	·665	1 ,, 5·782	6·23	1·75			
15 Sewage	10.30 p.m. to 12.30 a.m.	37,447	3·920	3·206	·602	2·513	1 ,, 4·174	8·61	2·85	19·8	14·62	5·18
16 Effluent			·686		·126	·847	1 ,, 6·72	6·30	1·47			
	March 3rd, 1885.											
17 Sewage	12.30 to 2.30 a.m.	35,917	3·518	3·122	·563	2·317	1 ,, 4·115	8·4	2·19	14·0	11·2	2·8
18 Effluent			·728		·119	·630	1 ,, 5·294	6·30	1·31			
19 Sewage	2.30 to 4.30 a.m.	40,552	4·256	·994	·157	·833	1 ,, 5·305	5·18	1·09	83·5	48·92	34·58
20 Effluent			·840		·154	·798	1 ,, 5·182	6·37	1·63			
21 Sewage	4.30 to 6.30 a.m.	35,917	12·530	·672	·073	·616	1 ,, 8·438	4·69	1·09	305·6	150·62	154·98
22 Effluent			·910		·157	·840	1 ,, 5·35	6·58	1·09			
23 Sewage	6.30 to 8.30 a.m.	37,447	2·002	·504	·045	·434	1 ,, 9·644	4·62	·21	57·5	37·2	20·3
24 Effluent			·980		·182	·861	1 ,, 4·730	6·65	1·14			
Sewage	Averages.	540,807	4·076	1·758	0·271	1·58	1 ,, 6·979	6·29	1·74	59·97	34·89	25·08
Effluent		TOTAL FLOW.	0·677		0·118	0·651	1 ,, 5·682	6·20	1·24			

Observations taken at 12 noon on March 2nd, 1885:—Barometer, 29·8; maximum temperature, 48° F.; minimum temperature 24° F.; rainfall, nil.

* This effluent contained decidedly the largest amount of suspended matter. It was the only effluent in which the suspended matter was determined.

NO. 3 SERIES.

SEWAGE WORKS, AYLESBURY.

Table showing Results of Analyses of Samples of Sewage and Effluent taken at intervals of half-an-hour from 8.30 a.m. March 16th to 8 a.m. March 17th, 1885. For the purposes of Analysis, equal portions of four consecutive half-hour samples were mixed together.

Number of Sample.	Time.	Flow of Sewage.	GRAINS PER GALLON.				Ratio between Distillate and Residue.	GRAINS PER GALLON.				
			Oxygen Absorbed by									
			Unfiltered.	Filtered.	Distillate	Residue of Distillate.		Chloride.	Ammoniacal Nitrogen.	Total Suspended Matter.	Organic.	Inorganic.
	16th March, 1885.	gallons.										
1 Sewage	8.30 to 10.30 a.m.	23,803	1 86	·98	·108	·97	1 to 8·98	5·95	·54	25·76	10·78	14·98
2 Effluent			·84		·09	·805	1 ,, 8 94	7·42	2·41			
3 Sewage	10·30 a.m. to 12.30 p.m.	32,813	22·2	1·90	·32	1·71	1 ,, 5·34	7 63	4·15	560·9	306 1	254·8
4 Effluent			·79		·09	·77	1 ,, 8·5	7·35	2·24			
5 Sewage	12.30 to 2 30 p.m.	37,476	8·65	3·65	·55	2·70	1 ,, 4·91	8·12	5·15	169·9	98·0	71·9
6 Effluent			·75		·09	·77	1 ,, 8·5	7·21	1·75			
7 Sewage	2.30 to 4.30 p.m.	31,685	7 37	2·21	·19	2·61	1 ,, 6·69	7·14	3 78	193·0	111·6	81·4
8 Effluent			·84		·09	·77	1 ,, 8·5	7·21	2·08			
9 Sewage	4.30 to 6.30 p.m.	34,699	5·18	2·87	·44	2 91	1 ,, 6·61	8·75	3·12	71 82	45·64	26·18
10 Effluent			·81		·10	·74	1 ,, 7·4	7·14	2·08			
11 Sewage	6.30 to 8.30 p m.	43,696	7·16	1·82	·25	1 63	1 ,, 6·52	5·46	1 71	245·5	149·6	95·9
12 Effluent			·95		·15	·79	1 ,, 5·26	7·21	2·19			
13 Sewage	8.30 to 10.30 p.m.	29,026	8·47	1·56	·26	1·70	1 ,, 6·54	6·51	2·85	241·0	146·4	94 6
14 Effluent			·98		·16	·90	1 ,, 5·62	7·35	2·41			
15 Sewage	10.30 to 12.30 p.m.	24,797	2·32	1·73	·29	1·56	1 ,, 5·38	8 47	2·41	17·7	11·9	5·8
16 Effluent			·98		·18	·99	1 ,, 5 5	7·35	2·08			
	17th March, 1885.											
17 Sewage	12.30 to 2.30 a m.	26,419	1·76	1·34	·21	1·21	1 ,, 5·76	6·09	1·35	10·7	5·6	5·1
18 Effluent			1·06		·19	·97	1 ,, 5·10	7 14	2·20			
19 Sewage	2.30 to 4.30 a.m.	25,260	2·11	1·14	·20	1·02	1 ,, 5·1	5·67	1 42	68·8	24·7	44·1
20 Effluent			·98		·20	·90	1 ,, 4 65	7·14	2·14	·98*		
21 Sewage	4.30 to 6.30 a.m.	24,334	6·18	·75	·07	·59	1 ,, 8·42	5·25	·98	775·8	341·3	434·5
22 Effluent			1·12		·15	·91	1 ,, 6·06	7·28	2·08			
23 Sewage	6.30 to 8.30 a.m.	24,739	8·31	·92	·10	·73	1 ,, 7·3	5·32	·87	434·7	153·7	251·0
24 Effluent			1·05		·24	·84	1 ,, 3·5	7·21	2·03			
Sewage	Averages.	358,747	6·8	1·74	0·266	1·61	1 ,, 6·05	6 61	2·37	234·63	119·61	115·02
Effluent		TOTAL FLOW.	0·93		0·14	0·90	1 ,, 6·43	7·25	2 14			

Observations taken at noon on March 16th, 1885:—Barometer, 30·2; maximum temperature, 61° F.; minimum temperature, 22·5° F.; rainfall, *nil.*

* This effluent contained decidedly the most suspended matter. It was the only effluent in which the suspended matter was determined.

The materials used for the precipitation of the sewage matters are clay, carbon, blood and alum, and they are manipulated as follows:—Weighed quantities of the clay and carbon are ground together in a mill with a certain small proportion of blood and some water. When thoroughly incorporated, the mixture is run into a reservoir placed beneath the mill, where a considerable proportion of the heavier clay particles subside, whilst the lighter particles of clay and carbon are added to the sewage as above described. The sulphate of alumina is dissolved in a separate tank, and is run directly from this into the sewage. The solution of alum used was found to contain on an average from 1 to 2 per cent. of sulphate.

Before generalising on the three series of experiments, it is necessary that we should consider each series separately, because although the same general system of research was adopted, yet modifications were introduced into each, with a view of bringing out more clearly the probable influence of certain conditions.

No. 1 Series.

(*From* 8 *a.m. on January* 29*th*, *to* 8 *a.m. on January* 30*th.*)

In the first series, especial attention was paid to the matters in suspension and in solution, both in the sewage and effluent, and the relation between the organic and inorganic portions respectively. The nitrogen, chlorine, and organic matter were also determined.

We considered that the estimation of the quantity of organic matter present (especially the organic matter in the effluent) was of the first importance, and this we determined by the amount of oxygen required to oxidise it. By this method all the easily oxidisable substances are taken into account, including, at any rate, the organic matter especially liable to decomposition, and therefore those constituents particularly active in affecting the purity of a river by absorption of the dissolved oxygen of the stream.

The determination of the chlorine (present in the sewage in the form of chloride of sodium) was important, as indicating the strength of the sewage operated upon. At the same time we consider too much importance should not be attached to this ingredient, seeing that in an inconstant liquid like the sewage of a town, a large proportion of common salt may be derived from sources other than human excreta. The fact that the effluent generally contained slightly more chlorine than the raw sewage, is to be explained by the appreciable quantity of chloride introduced along with the materials used as precipitants.

The principal characteristics of No. 1 series are the large flow, the dilute condition of the sewage, and the excessive quantity of precipitating mixture used in its treatment. The flow measured nearly 500,000 gallons, instead of 300,000, which we are informed is about the normal quantity. This dilution in great part accounted for the diminished strength of the sewage operated upon during the week. The average amount of oxygen required to oxidise the organic matter was in the sewage 1·795 grs. per gallon, and in the effluent 0·522 grs.; in other words, 74·8 per cent. of the oxidisable organic matter had been removed by treatment, a result, in our opinion, satisfactory. Again the total suspended matter in the sewage averaged 18·8 grs. per gallon, whilst that in the effluent was 1·92 grs. per gallon, in other words the removal of 89·3 per cent. of the suspended matter had been effected. The ratio of the inorganic to the organic in this suspended matter was in the sewage as to 1 to 1·18, and in the effluent as 1 to 6, showing that the small amount of suspended matter left in the effluent was principally organic. The matters in solution show a mean of 46·3 grs. per gallon in the raw sewage, and of 57·5 grs. per gallon in the effluent. This excess of soluble matter in the effluent depends on the large quantity of soluble salts introduced in the A B C mixture.

The mean quantity of nitrogen in the form of ammoniacal salts and of chlorine in the sewage and effluent are practically identical, and do not call for comment.

The total quantity of sludge produced can only be given approximately. An excessive quantity of precipitating material was in our opinion employed, and the subsequent series prove that the use of this large amount does not in any way improve the efficiency of the process. The curves plotted for this series illustrate graphically the variations, both in sewage and effluent, from hour to hour, and are useful as a ready method of noting the particular phases of the sewage and of the effluent at any hour of the day or night.

The irregularity of the lines representing the constituents of the sewage, and the comparative straightness of those representing the effluent, will at once be apparent; the high crest wave, indicating the maximum in the amount of all the sewage constituents between 12 noon and 6 p.m., being especially noticeable.

No. 2 Series.

(*From* 8.30 *a.m. on March* 2*nd*, *to* 8.30 *a.m. on March* 3*rd.*)

The second series was devoted more especially to a consideration of the character of the organic matter as it exists in the sewage and in the effluent respectively. We considered it important, moreover, from a sanitary point of view, to determine the relative amounts of volatile and fixed organic matter.

For this purpose each sample of sewage was filtered, and the total organic matter determined, both in the unfiltered and filtered portion.

A certain quantity, therefore, of each sample of the filtered sewage was subjected to distillation, and the organic matter determined both in the distillate and in the residue left in the retort. The effluent was treated similarly, except that being practically free from suspended matter it did not require any previous filtration.

In this series the oxygen required to oxidise the organic matter in the unfiltered sewage averaged 4·076 grs. per gallon, whilst that required by the effluent was 0·677 grs. per gallon. Thus 83·3 per cent. of the oxidisable organic matter had been removed by treatment—a result, in our opinion, satisfactory.

The filtered sewage required an average of 1·75 grs. of oxygen to oxidise the organic matter per gallon; 61·4 per cent. therefore of the oxidisable organic matter in solution had been removed.

The ratio of the volatile to the stable organic matter was, in the sewage as 1 to 6·9, and in the effluent as 1 to 5·7; that is to say, only one-seventh of the soluble organic matter in the sewage, and about one-sixth of that in the effluent, was volatile along with the vapour of water.

The chlorine and ammoniacal nitrogen were again estimated, and, as before, were almost identical in amount, both in sewage and effluent.

The mean amount of suspended matter in the sewage was 59·97 grs. per gallon. Owing to the extremely small quantity in the effluent, it was thought unnecessary to determine it in every sample in this series. The one selected for estimation, as containing the largest amount, gave 1·89 grs. per gallon. Reckoned on this high estimate it shows that 96·8 per cent. of suspended impurities had been removed by treatment. This series also showed a great improvement in the deposition of the sludge. The quantity of precipitating material used was only slightly more than one-third of the total weight of sludge produced, the absence of any appreciable amount of suspended matter in the effluent proving that efficiency was not impaired by the small quantity of material employed.

The chief characteristics, therefore, of No. 2 series are the very large flow, the greatly increased strength of the sewage, and the improved working of the process, both as regards the sludge deposited and the per-centage of organic matter removed.

This improvement can at once be seen by an examination of the curves for this series.

NO. 3 SERIES.

(*From* 8.30 *a.m. on March* 16*th, to* 8.30 *a.m. on March* 17*th.*)

This series of observation was taken, not only with the object of corroborating the other two, but principally on account of the very dry weather which had prevailed for the previous fortnight, and the unusual strength of the sewage at the time. We deemed it advisable to ascertain how the process would work under extreme conditions of a small flow and abnormally rank sewage.

The samples were examined in the same manner as the No. 2 series, the organic matter being divided into the volatile with water vapour, and the fixed (that is, not volatile with the vapour of water).

We consider that this method gives a certain insight into the nature of the organic matter present.

On considering our results in detail, it is apparent that a still further improvement has been effected in the working of the process.

Commencing with the organic matter, the average oxygen required by the raw sewage reached 6·8 grs. per gallon, whilst in the effluent it was 0·93 gr. per gallon, showing a removal of 86·3 per cent. of the oxidisable organic matter.

The relation between the volatile and the stable organic matter in the filtered sewage and in the effluent was almost identical with that of the last series, being as 1 to 6·0 and 1 to 6·4 respectively.

On turning to the matters in suspension, a striking result was obtained. The quantity in the sewage reached the abnormally large amount of 243·6 grs. per gallon, while the effluent was so uniformly devoid of turbidity that the sample taken for the estimation of the suspended matter, as containing a larger amount than any other, only gave 0·98 grs. per gallon.

In this series the sludge did not show quite so good a relationship to the precipitating materials, the total quantity deposited in the 24 hours being about half that of the number 2 series. This is explained by the flow of sewage being very much less.

The chlorine and ammoniacal nitrogen were again about the same in the sewage and effluent, a remarkable uniformity in this respect being apparent.

The characteristics of this series are somewhat different from those of the other two, viz., a much smaller flow (in fact, what is considered a normal flow), and an exceptionally strong and rank sewage. It will be seen by studying the curves relating to this series, that this exceptional state of things has not only not interfered with the proper working of the process, but that the results obtained are positively better than in the other two series.

SUMMARY.

Reviewing and generalising upon the results thus detailed, the following facts seem to us established:—

In the first place, there is no doubt that the A B C process is capable of producing a uniform effluent, notwithstanding the very varied nature and concentration of the raw material to be dealt with.

The quality of the effluent, however, more especially as relates to the quantity and kind of dissolved organic matter, unquestionably depends upon the strength of the original sewage. This will be seen by comparing the following numbers for the three series:—

	1	2	3
Average amount of oxygen absorbed by organic matter in the sewage	1·79	4·07	6·8
„ „ „ effluent	0·52	0·67	0·93
Per-centage of oxidisable organic matter removed	74·80	83·30	86·30

This, in our judgment, is a satisfactory result, because although the effluent is certainly not so good as in the case of a strong as with a weak sewage, nevertheless the efficiency of the process is proved to be actually greater with regard to the total quantity of organic matter removed, a result we hardly anticipated. Too much importance must not be attached to the numerous isolated cases in which as little as 0·2 or 0·3 grs. per gallon of oxygen was required to oxidise the organic matter in the effluent, it being found that the sewage operated upon was in these cases excessively dilute.

There seems no reason to doubt that a minimum quantity of organic matter in the effluent might be permanently maintained, if the weak nightly sewage could be stored in reservoirs and afterwards mixed and treated along with the stronger day sewage, or if the effluent was collected in large reservoirs and allowed time to mix and become of a more uniform character before discharge.

With regard to the removal of the suspended matter the process is satisfactory, and there is no doubt that an effluent can easily be obtained with due care (and this irrespective of the original sewage) practically clear, that is containing less than 1 gr. of suspended matter per gallon. In fact the precipitation appears to be more complete as the quantity of suspended matter in the raw sewage increases.

The chlorine, though it increases regularly with the strength of the sewage, shows a slight increase in the effluent, owing to the quantity introduced by the precipitating materials.

The nitrogen, in the form of ammoniacal salts, also seems to be unaffected by the process, being in all three series practically the same in amount, both in the effluent and in the sewage.

With respect to the removal of any soluble inorganic salts by the process, it is difficult to speak with precision, owing to the quantity introduced by the precipitating materials, whilst the phosphoric acid, which principally exists in the urine, is no doubt precipitated as phosphate of alumina. The soluble organic matter precipitated from solution is also considerable, amounting in No. 2 series to 61·4 per cent., and in No. 3 series to 57 per cent. of the whole.

The organic matter in the effluent is evidently mainly composed of the salts of fatty acids and such like bodies. The fact that on evaporating down a large quantity of the effluent, and throwing it on a dialyser or diffusible membrane, at least two-thirds of the organic matter diffused, showed that it could not be of an albuminous or complicated colloidal nature, and was, therefore, of a nature less liable than these bodies to putrefactive and other changes. This conclusion is further borne out by a consideration of the volatile alkaline and acid portions of the organic matter. Dividing the readily oxidisable organic matter into six parts, the relation between them was as follows:—1 part volatile and alkaline; 2 parts volatile and acid; 3 parts non-volatile.

EXAMINATION OF THE SLUDGE.

The second part of the A B C process consists in the drying of the sludge, and its conversion into a saleable manure, known under the name of native guano.

The following is a brief account of the different stages of the working:—The semi-liquid sludge in the tanks, containing about 90 per cent. of water, is pumped into a large reservoir situate on the roof of a tower some 40 feet high, and immediately above the filter presses. Here it is allowed to settle. The comparatively clear water lying on the surface, as well as the expressed fluid of the sludge, are both returned to the sewer just above the sewer mouth, to be again treated along with the raw sewage, and with which it mixes.

The sludge is now run into the two large filter presses, and as the water is squeezed out fresh quantities of sludge are turned into the presses by a special feeding arrangement until they are full. The sludge, as it comes from the filter presses, is in the form of stiff cakes, containing from 55 to 60 per cent. of water. This material, after admixture with some sulphate of magnesia, is then passed through a specially constructed drying cylinder, which delivers it in a more or less granular condition. This operation extracts about 25 per cent. more of the water, the granular manure containing now from 30 to 35 per cent.

The water evaporated from the semi-fluid sludge is condensed in a coke tower, through which a stream of water falls continuously, effectually preventing the dissemination of any offensive smell into the surrounding air.

From the drying shed at the works the manure is removed to a large depôt in the town, where by grinding it is reduced to a coarse powder. Here it is stacked in a shed and placed in bags for the market. Although no further artificial drying is resorted to, it gradually loses more and more of its moisture by air drying, and is usually sold with from 14 to 18 per cent. of moisture in it.

The native guano is in fact nothing but the partially dried precipitated sludge, mixed with some sulphate of magnesia and ground. The one curious part of the process is, the large amount of heat developed in the interior of the heaps of the cylinder dried manure, both before and after grinding. This continues for many months in the stacked manure without any apparent diminution. The temperature varies slightly according to the depth of the heap at which it is registered, but finally reaches a maximum of about 113° F., at which it remains stationary for months.

There is no appearance of steam or other sign of heating on the surface of the heap, but when turned over about a foot deep, dense clouds of steam having a distinct smell of ammonia and showing an alkaline reaction to litmus paper, are evolved.

It was thought, therefore, that a very appreciable loss of ammonia must result from this action, and for the purpose of testing this, samples of the gases evolved from the centre of the heap were collected and examined. The result show however that these contained only ·01 per cent. of ammonia and 5 per of carbonic acid, suggesting that the heating action was due to oxidation and not to any fermentative process involving a loss of ammonia. What is very remarkable, however, is that the absorption of oxygen does not seem to involve a production of nitrates, which is the usual accompaniment of combined fermentative action and oxidation, and indicates in this case that the oxidation is probably mainly confined to the non-nitrogenous constituents of the sludge.

In order to decide the possible loss of ammonia in the preparation and subsequent heating, samples of the pressed sludge and of the manure both before and after grinding were submitted to the continuous action of a current of dry air at 212° F. for some hours. By this means we were enabled to determine the amount of ammonia that could really be driven off under exceptional circumstances. The ammonia was estimated, both in the dried portion and in that portion driven off by heat, the total quantity in the dry manure being also determined.

The results obtained are stated in the following Table:—

No.	Description of sample.	Per-centage of moisture.	Ammonia, per cent.		
			Loss at 212° F.	In dry sludge.	Total in manure.
1	Sludge direct from press, 13/2/85	61·8	·072	3·23	3·302
2	,, ,, ,, 26/2/85	57·4	·080	3·39	3·570
3	,, immediately after passing through cylinder	51·1	·003	3·10	3·103
4	Dried sludge, after lying about three weeks at works ..	30·3	·170	3.80	3·970
5	,, ,, ,, at depôt about three weeks ..	33·7	·480	3·41	3·890
6	Manure, immediately after grinding	31·7	·200	3·87	4·070
7	Ground manure from front of heap, 1 yd. deep	29·6	·350	3·59	3·940
8	,, ,, ,, top of heap (ground about two weeks)	35·4	·303	3·55	3 853
9	Ground manure from side of heap, 1 yd. deep (about one month)	34·3	·320	3·52	3·840
10	Ground manure from centre of heap, 1 yd. deep (ground five months)	28·0	·270	3·94	4·210
11	Ground manure from back of heap, 1 yd. deep (ground seven to eight months)	17·2	·120	3·61	3·730

The above Table shows that a small proportion only of the ammonia is evolved even at the temperature of boiling water, a fact that was further confirmed by passing several cwts. of the sludge a second time through the drying cylinder. In this way we obtained a manure containing only 20 per cent. of moisture without its manurial value being sensibly affected so far as the loss of available ammonia was concerned. It will also be seen that the average total amount of ammonia is practically the same from every part of the stacked heap, not being effected by the continuous action of heat after several months.

The per-centage of combined nitrogen in the manure is consequently remarkably constant, and amounts to an average of 3·8 per cent. reckoned as ammonia in the perfectly dry manure, or if with 20 per cent. of water, to 3 per cent. of available ammonia.

As the phosphoric acid is also an important ingredient from a manurial point of view, it was estimated in four samples of the manure taken from different parts of the heap, an average of 5·0 per cent. reckoned as tricalcic phosphate of lime being found. As to the manurial value of the native guano, we are strongly of opinion that this must be judged rather by the practical results of the agriculturist than by presumed theoretical values based on analytical data, and on the price of ingredients not necessarily in the same physical or chemical condition. Recent research tends to show that very small changes brought about in soils may have very important indirect effects.

We desire to express our obligations to Gerrard Ansdell, Esq., F.C.S., for the ability and attention he has devoted to this inquiry.

We remain,
Your obedient Servants,
C. MEYMOTT TIDY.
JAMES DEWAR.

April 29th, 1885.

PHOSPHORIC ACID, MAGNESIA AND LIME. *Herapath's Process—Blythe's Process.*—The object of this mixture as a sewage precipitant is to fix the ammonia (as an insoluble ammonio-phosphate of magnesia) which in the employment of lime, or iron and alumina salts, remains in solution in the effluent, and consequently is lost. The lime, however (in common with iron and alumina salts) precipitates the phosphoric acid in the sewage. The use of sulphate or chloride of magnesium as a precipitant, in order to form the insoluble ammonio-phosphate of magnesia, was first suggested by Sir James Murray. Herapath, in 1853, patented a process for the use of magnesia or one of its compounds, in order to precipitate the ammonia and phosphoric acid "at or about the same time as the deodorisation of the same sewage is effected by the addition of some chemical agent which will not decompose ammonia or its salts."

With this object he employed a mixture of 1 part of sulphate of iron, and 4 parts of burnt magnesian limestone. The process was tried at the Sewage Works of St. Thomas, near Exeter, but proving unremunerative, was abandoned.

Murray and *Herapath's* process did not meet with the approval of Hofmann and Witt, on the ground that 1 part of the ammonio-phosphate of magnesia is soluble in 45,000 parts of water containing free ammonia and in 15,000 parts of pure water, whilst in a water containing a salt of ammonia, it was soluble to the extent of 1 in 7,000 parts.

In 1858, *Blythe* (Consulting Chemist of the Board of Health) patented the use of a solution of phosphate of magnesia in combination with lime or other precipitating agent.

The following is his description of the process:—

> "Superphosphate of magnesia is first to be prepared by the mutual decomposition of superphosphate of lime and a salt of magnesia, the superphosphate of lime being obtained from bones, bone-ash, apatite, phosphorite, coprolite, phosphate of alumina, phosphate of iron, phosphate of copper, or any other substance containing phosphoric acid, by the aid of sulphuric or muriatic acid, or other acid, the proportions being, in the case of phosphate of lime, one ton of phosphate to half a ton of sulphuric acid of commerce, previously mixed with three times its weight of water, or three-quarters of a ton of hydrochloric acid of commerce diluted with twice its weight of water. These are allowed to stand together for two or three days, being frequently stirred, and then they are mixed with a ton of sulphate of magnesia, dissolved in a small quantity of water, say a little more than its own weight. Powdered charcoal is then added in sufficient quantity (about one ton) to bring the mixture into a solid and convenient form for transport. When used for the purification of sewage, it is to be dissolved in water, and added to the sewage in the proportion of five parts of the phosphate to every 100 parts of solid matter in a gallon of the sewage. The whole is then to be well mixed and thoroughly incorporated by means of an agitator. If the sewage does not contain enough free ammonia or other alkali to neutralise and precipitate all the superphosphate of magnesia, lime is to be added, in the form of milk of lime, until the sewage is faintly alkaline to test paper. By this means the ammonia-phosphate of magnesia is thrown down as a flocculent precipitate, which carries with it, after the manner of a clarifier, any insoluble impurities suspended in the liquid. In like manner, instead of lime, he claims the use of any other alkali or alkaline earth, as potash, soda, magnesia or magnesian limestone, or alumina. He thus produces a valuable manure, containing, as he supposed, the ammonia, as well as the nitrogenous organic matter of the sewage, and the phosphoric acid employed; 'while the supernatant liquor being freed from ammonia and nitrogenous matter, liable to undergo putrefaction, becomes deodorised, and may be either applied to the irrigation of land, or run off into the ordinary channels of drainage without fear of creating any nuisance or offence.'"

Way, in 1861, in the second report of the Commission to inquire into the best mode of distributing the sewage of towns, condemned the process as the most costly of all the plans that have been proposed, but on grounds that scarcely commend themselves to our judgment. I am ready to admit that the process may fail in removing the ammonia to the extent indicated by the patentee, but how it can possibly fail in removing the phosphoric acid (I am arguing now on chemical grounds), as Way's analyses show, is beyond comprehension. The only explanation can be that Mr. Way did not use sufficient lime.

Many experiments were made with Blythe's mixture, of which the following are illustrations.

	Matter in Solution.				Matters in Suspension.		
	Total Solids.	Phosphoric Acid.	Ammonia.	Oxygen Required.	Total Solids.	Organic.	Mineral.
Metropolitan.							
Raw Sewage	68·33	·64	6·33	2·54	47·42	27·51	19·91
Effluent	90·02	·60	6·24	1·41	0	0	0
Coventry.							
Raw Sewage	46·61	·53	1·16	·78	21·11	8·87	12·24
Effluent	68·07	·05	1·06	·43	0	0	0

Superphosphate of magnesia was added, in the proportion of 10·3 grains of phosphoric acid per gallon, and then an excess of lime until the sewage was faintly alkaline.

The dried precipitates had the following per-centage composition: —

Organic matter	28·06	12·16
Phosphate of lime	27·11	32·65
Earthy matters	35·30	45·60
Sand, &c.	9·53	9·59
	100·00	100·00
Nitrogen equal to ammonia	1·61	0·99

The process purified the sewage successfully. One ton 3 cwt. of the superphosphate compound and 4 cwt. of lime was found on an average to be required for 1,000,000 gallons. This produces 3 tons 1 cwt. of a manure valued at £3 14s. per ton, the chemicals and labour to produce which cost £1 15s., leaving a net profit of £1 19s.

Blythe's later experiments showed that the magnesian compound might be omitted, and that the precipitated phosphate of lime was as valuable for plants as the original superphosphate.

Arrangements had been made to try the process at Southampton and Leicester, but fell through owing to the death of the patentee.

PHOSPHORIC ACID, LIME, AND ALUMINA.—PHOSPHATE SEWAGE PROCESS.

The patent of Mr. *David Forbes*, F.R.S., and of Dr. *Astley Paston Price* was taken out in 1870. It consisted in the use of an acid solution (sulphuric acid being generally employed) of natural phosphate of alumina, with or without lime or carbonate of lime. The object was to employ a precipitant of manurial value, in order to obtain a compost of high fertilising power.

The phosphate of alumina was obtained from the West Indies, where it occurs in such enormous quantities that on one island alone the deposit is estimated at 9,000,000 tons. It contains about 38 per cent. of phosphoric acid and 25 per cent. of alumina, with about 2·5 per cent. of peroxide of iron. It was formerly supposed to be phosphate of lime, but analysis shows that the material does not contain more than 2 per cent. of lime.

The following is the description of the process given by the patentees:—

"In carrying out the invention they say, we firstly submit to the action of sulphuric or muriatic acid the natural phosphates of alumina; which phosphates of alumina are capable of being decomposed and rendered soluble by the employment of sulphuric or muriatic acid. Having converted the phosphates into a soluble condition, or having obtained a solution of the phosphates of alumina, they may either be employed in their concentrated form, or a solution of the same may be diluted, and they are then in a fit and proper condition to be employed for the treatment of sewage. Whilst the sewage is contained in a cistern or reservoir, or whilst it is in the act of flowing thereinto, the requisite proportion of the soluble phosphates of alumina is to be added thereto, and after thorough admixture with the sewage by the use of agitators, or other well-known means, the sewage so treated may be allowed to remain tranquil in the reservoir in order that subsidence of the resulting precipitate may be effected, or after having added to the sewage the requisite amount of the soluble phosphate of alumina, lime (by preference in the form of milk of lime) is to be added in such quantity as that the phosphates in solution shall be precipitated. This result will be known by the sewage acquiring a neutral or alkaline reaction, or the lime may be firstly added, and the solution of the phosphates of alumina added subsequently, but we prefer the former process, or the soluble phosphates of alumina may be firstly decomposed by means of lime or carbonate of lime, and the resulting precipitate may be employed for the purpose of effecting the separation of certain constituents of sewage.

"In conjunction with any of the before-mentioned methods of carrying out our invention, deodorising agents, such, for example, as animal or vegetable charcoal, may be employed, but good results will be obtained by the employment of the phosphates of alumina alone, or in conjunction with lime as before mentioned. The sewage, after treatment by either of the before-mentioned processes, is allowed to settle, and the clear or supernatant water may be run off, and the deposit or precipitate collected and removed, and employed for agricultural purposes either in the moist condition, or after having been submitted to a drying or desiccating process. Or the precipitated phosphates may be again submitted to the action of sulphuric acid, and the solution be again employed for the treatment of sewage in a manner similar to that before described. The proportions in which the soluble phosphates of alumina may be employed will vary with the sewage to be operated upon, and the quality of the manure desired to be obtained. We have obtained good results by the employment of about two parts by weight of the soluble phosphates of alumina to every one thousand parts by weight of sewage treated, but we do not limit ourselves to such proportions."

Our experiments with London and Coventry sewage, in which we added 33 grains per gallon of the phosphatic material (= 10·38 grains of phosphoric acid) dissolved in its own weight of commercial sulphuric acid, gave results as follows:—

	Matters in Solution.				Matters in Suspension.			
	Total solids.	Phosphoric acid.	Ammonia.	Oxygen required.	Total solids.	Organic.	Mineral.	Phosphoric. acid.
London.								
Raw sewage......	68·33	0·64	6·33	2·54	47·42	27·51	19·33	0·68
Effluent..........	100·07	0·68	5·70	1·44	0	0	0	0
Coventry.								
Raw sewage......	46·61	0·53	1·16	0·78	21·11	8·87	11·96	0·28
Effluent..........	82·59	0·60	1·04	0·47	0	0	0	0

The dried precipitate gave as follows:—

	London sewage.	Coventry sewage.
Organic matter	24·80	10·40
Phosphate of lime	16·82	22·11
Carbonate of lime and magnesia	49·39	58·14
Silica, &c....................	8·99	9·34
	100·00	100·00
Nitrogen equal to ammonia	1·41	0·91

The effluent was clear and without smell, much soluble organic matter being removed. The process, however, is peculiar in this respect, that if no lime be added after the precipitating material, much soluble phosphate will remain in solution. The effluent may then be used for irrigation, no nuisance being likely to result from the use of the clarified water, the manurial value of which will be considerable. In other words, we strengthen (the patentees would say) the manurial value of the sewage, and purify it by the same operation.

If lime be used, the deposit may be made to contain any proportion of phosphate of lime (indeed it may be rendered almost pure bone earth), necessary to pay its cost of carriage to a distance. Thus to effect a good sanitary result a small quantity only of precipitating matter is required, whilst a commercial success may be effected by the use of a large quantity of the precipitant. Thus, if two tons of the phosphate be added to every 1,000,000 gallons of London sewage, it would yield four or five tons of manure, containing 15 to 18 per cent. of phosphoric acid, whilst if three tons be added per million, a manure would be obtained worth, according to Voelcker, £7 7s. per ton, and having a composition as follows:—

	Per cent.
Moisture	3·98
Organic matters .	20·11
Phosphoric acid..	28·52 = 62·26 tribasic phospheric of lime.
Lime	13·09
Alumina, &c....	29·95
Sand, &c.	4·35
	100·

Nitrogen 0·57 = to ammonia 0·69.

The only place where the process was worked to which we need refer is *Hertford*, where the process was in operation for two years (1876-1877). The results were good, but no details are given as to cost. The company paid £100 per year rent for the works, and received £300 per year as a subsidy from the corporation, *i.e.*, at the rate of 7d. per head of the population.

Whitthread's Process (1872).—The patentee employs superphosphate with a little milk of lime, the object being to recover the phosphoric acid in the sludge.

It was used at the following places:—

Romford Sewage Farm.—Tried by Colonel Hope, and mentioned by him with approval, in 1872, at the Social Science Congress.

Luton (*Bedfordshire*).—Used in 1874. Not successful.

Enfield (1874).—Was considered successful, but abandoned on the ground of cost.

Tottenham (1874).—18 cwt. of chemicals was added per 1,000,000 gallons, at a cost of £3 2s. The sludge was dried, its value being estimated at £4 3s. 6d. per ton, the cost of production being £3 8s. 9d. The purity of the effluent was questioned, owing to the quantity of phosphoric acid in solution. The process was soon abandoned, owing to the liquidation of the company.

Dugald Campbell's Process (1872).—The patentee employs superphosphate and some lime. It was tried at Tottenham in 1872 for six days on 3,500,000 gallons, at a cost for chemicals of £16 6s. 5d. per million gallons, yielding 6·3 tons of manure per million, valued at £5 per ton.

It was also tried experimentally (1873 to 1875) on the metropolitan sewage, when the chemicals required to produce a good effluent were found to cost at the rate of £22 6s. per million gallons. The dry manure was valued at from £3 15s. to £4 15s. per ton.

SALTS OF IRON.

Brown (Feb. 1847) patented the use of the sulphates and chlorides of iron as sewage disinfectants, and *Ellerman* (Oct. 1847) the use of the chlorides and pyrolynates (acetates) of iron. Ellerman's fluid (price 1s. 6d. a quart retail, 9d. wholesale), contained from 24 to 43 per cent. of the iron salts named, and had a specific gravity of from 1336 to 1443. There was some division of opinion respecting its value, Letheby reporting that 100 grains of Burnett's fluid (sp. gr. 1594) had an equal deodorising power to 470 grains of Ellerman's fluid (sp. gr. 1443), a view supported by Mr. Haywood and others.

Dale's fluid (sp. gr. 1450, price 6d. per gallon), was a strong solution of perchloride of iron, and was proposed by Hofmann, Frankland, and Miller, for deodorising the Thames during the hot summers of 1857 and 1860, on the ground that it compared favourably, as regards cost, with lime or chloride of lime. Thus they said 1,000,000 gallons of London sewage required for deodorisation the following quantities of the several ingredients named:—

	Cost.		
	£	s.	d.
86 gallons of Dale's fluid	1	13	0
400 lbs. of chloride of lime....	2	2	10½
132½ bushels of lime	3	6	6

They remark that the sewage treated with lime became offensive after three days—with chloride of lime after four days—whilst that treated with perchloride of iron did not become offensive even after nine days. The use, however, of the iron was objected to by Odling and Letheby, both urging that a black mud would form in the river, which, after a time, would undergo putrefactive changes, and be more unsightly than even the sewage. Letheby also urged the quantity of arsenic in the perchloride as an unanswerable objection to its employment as a precipitant where the sludge is not removed before the treated sewage is allowed to escape into the river.

Dale's liquid (130 gallons to 1,000,000) was used at Croydon in 1852 and 1860. The results were not satisfactory, because the suspended matter was imperfectly removed, the iron sulphide giving the effluent a black and polluted appearance.

Dover's patent (1851) claims the use of acids with iron filings or oxide of iron and protosulphate of iron, the defœcated sewage being afterwards filtered through charcoal, peat, &c.

Mudie's disinfectant, a preparation of dry copperas, is valuable for the deodorisation of drains, &c., owing to its property of absorbing ammonia and sulphuretted hydrogen. It is hardly suited for the defecation of sewage, although it acts well as a general disinfectant, for which purpose it is largely used in the French slaughterhouses.

LIME, SULPHATE OF IRON, AND COAL DUST.—HOLDEN'S PROCESS.

This mixture, as a sewage precipitant, was patented by Jules Houzeau and Devedeix (1866), and was used at Bradford by Mr. Holden (hence known as *Holden's process*). The sulphate of iron was to be added first, and afterwards milk of lime mixed with coal dust. The use of clay is also mentioned in Holden's patent. The treated sewage then flows into subsiding tanks. A clear and inodorous effluent can be obtained, about one-half of the dissolved organic matter being precipitated. The manure is of little value.

Bradford.—The process was tried in 1868 on 130,000 gallons daily. It was reported against by the Rivers Pollution Commissioners, as giving a clear effluent, but of a quality worse than the original sewage, founding their opinion on the quantity of organic nitrogen present. They supposed that the putrescible organic matters in suspension passed into solution by this treatment. Further, they considered the hardness of the effluent an objection to its being allowed to pass into water-courses.

Marsden and Collins' Process consists in the use of lime, carbon waste from the prussiate manufacture, house ashes, soda, and perchloride of iron.

This process was used in 1874 at *Bolton*, in dealing with one-sixth of the sewage (population, 93,000). The cost of chemicals was given at £1 7s. 3d. per million gallons of sewage, the total cost being £7 14s. 5½d. per million.

Hanson's Process (1875) employs lime, black ash (tank waste, or refuse from alkali works, containing sulphides of calcium and sodium), and red hæmatite treated with sulphuric acid.

This process was tried at Leeds, the chemicals used being in the proportion of—

	Tons.	Cwts.
Lime	20	0
Black ash	4	0
Red hæmatite and oil of vitriol	1	6

Two tons, 16 cwt. and 1 qr. were added to every 1,000,000 gallons, at a cost of £2 5s. 8d. per million. The effluent was said to be good. Its use was discontinued in April, 1876.

A modification of this process is now in use at Leyton. The process was adopted in 1882 by the Golcar Local Board.

Goodall's Process (1875) employs lime, animal charcoal, ashes, and iron liquor (solution of sulphate of iron). It was claimed that the cost would be 7s. 6d. per million gallons (Leeds Clarifying and Utilisation of Sewage Company).

Leeds.—The process was tried at Leeds. Tried for three months in 1875. The chemicals were mixed in the following proportions:—

	Tons.	Cwts.
Lime	21	15
Carbon	13	15
Ashes	10	14
Iron liquor	—	4

Five tons 3 cwt. of this mixture was added per 1,000,000 gallons, at a cost for chemicals of £2 4s. per million gallons.

Newcastle-under-Lyme (population, 18,000; 700,000 gallons daily). This process was adopted between 1877 and 1881. In 1881, 30 acres of land was secured, 10 only being employed for irrigation. There are four precipitation tanks, 125 ft. × 25 ft. and 4 ft. deep; cost £1,100 per annum.

LIME AND AN IRON SALT.

At Ealing the lime (20 cwt. per week to 3,000,000 gallons) is added to the sewage in the course of its transit to the subsidence tanks. These tanks, each measuring 64 ft. × 10 ft. × 10 ft. deep, are divided into five compartments by cross planks, where the lime precipitate subsides. In the last sub-division of the tanks, the defœcated sewage is treated with an iron solution (crude sulphate 15 cwt. to 3,000,000 weekly). The sewage then flows upwards through two filter beds (No. 1, gravel, 30 ft. × 10 ft. × 2 ft. thick; No. 2, sand, 60 ft. × 10 ft. × 2 ft. thick), the effluent being clear and inoffensive when discharged.

At Northampton, in 1862, lime (as milk of lime) and chloride of iron (in solution) were used as sewage precipitants. The constituents were mixed together, and so decomposed, before they were added to the sewage [60 lbs. of solid chloride of iron, 12 bushels of lime to 400,000 gallons of sewage daily]. There was no mechanical contrivance to mix the sewage with the chemicals. The sewage after treatment passed into two subsiding tanks (40 ft. × 30 ft. and 60 ft. × 30 ft., each 5 ft. deep), from the second of which it flowed over a weir into an outfall channel a mile in length, being ultimately discharged into the River Nene. The tanks were worked for a fortnight, when the sludge was conveyed into pits, and mixed with the town refuse, the manure realising 1s. 9d. per load.

Letheby recommended adding the iron salt to the sewage first and the lime afterwards, and that some mechanical contrivance for stirring the treated sewage both after the addition of the iron and the lime should be adopted. He considered 4·5 grains of chloride of iron and 15 grains of lime per gallon was needed. These details were adopted, and the results obtained were excellent.

Some difficulty having occurred in procuring the chloride of iron, a solution was prepared on the works of 9·400 grains per gallon. A fit of economy then led the authorities to reduce the quantity to 0·006 grain of chloride of iron and 5·88 grains of lime per gallon, quantities manifestly insufficient, under which treatment it was seen and reported on by the Rivers Pollution Commissioners.

For a short period combinations of lime and salts of iron were used both at Clifton and Cheltenham.

Having now dealt with the various precipitants suggested, to throw down the suspended matter and coagulate a part of the dissolved slimy organic matter of sewage, let me note that these precipitants, for practical purposes, are lime, chloride of magnesium, sulphate and phosphate of alumina, and salts of iron, alone or in conjunction with each other. In addition to these, clay and other weighting bodies, together with charcoal and other absorbent substances, have been added under various patents.

In selecting a chemical precipitant, five main points present themselves to us:—

1. That, consistently with purity of effluent, the chemicals used should be cheap.

2. That the precipitant should act as a deodoriser, and disinfectant as well as a precipitant.

3. That the precipitated matters should subside rapidly.

4. That the maximum purity should be obtained with the minimum of deposit, in other words, with the smallest quantity possible of chemicals.

5. That the sludge should part with its water readily.

I now approach the really practical question, asked all over the country, from every sanitary authority, often in tones of painful despair, viz., *How shall we deal with our sewage?*

And here let me say, there is no one answer that can be given to this question. The adviser, to advise fairly, must be prepared to sink his hobby, be it the hobby of precipitation or the hobby of irrigation, remembering that whilst conditions favourable to his hobby may exist at one place, conditions absolutely unfavourable may exist at another. Further, it is of no use telling how some pet plan, say, of irrigation or of precipitation, has succeeded at some one place or another, persuading local authorities to undertake a pilgrimage of inspection (although they are usually ready enough to do), and arguing that because such and such plan has succeeded at A, therefore it will succeed at B. There is no universal remedy for the sewage difficulty, and no one plan of treatment to be laid down.

When people say, "The whole thing is easy enough, only do this or do that," be certain they have not grasped the difficulties of the subject, and, I fear, know little about it.

Let me attempt, however, to suggest certain fundamental propositions that may serve as a starting point in advising local authorities:—

1. Towns must be prepared to pay to be clean. You will never be able to make your sewage pay your rates;—on the contrary, experience shows that you must purify your sewage at the expense of the rates.

2. That health demands that your sewage should be got rid of, and purified at any cost. Minimise the cost, but pay you must for purification. Hence, you must be prepared not only to borrow money to erect works, but for an annual expenditure after the works have been erected.

3. That no matter how perfect your works, your sewage will require constant attention, Sunday as well as week-day, night as well as day.

4. That to let unpurified sewage pass into a stream means passing your filth on to your neighbours. Sewage ought to be treated where the sewage is produced, as far as it is possible. And, considering this aspect of the subject, let me add, litigation is a more expensive luxury than sewage treatment, and breeds, if possible (although on this I admit a doubt), more ill-will.

5. That although our duty is to do our work well, at as small a cost as possible, we neither require (*quâ* the effluent) to produce a drinking water, nor (*quâ* the sludge) to produce Peruvian guano.

Our sewage has to be treated. We shall necessarily inquire how much sewage there is to treat, and what kind of sewage it is.

Let me suppose that our first thought is the possibility of an irrigation scheme.

Far be it from me to say that irrigation may not prove successful. But it is fair to note that, to attain the end of a sanitary authority, experience has shown that the sanitary authority must itself be the proprietor of the land. If you give the sewage to the farmers (supposing they would accept your gift) the interests of the local authority and of the farmers are opposite. For it is manifest that the interest of the farmer is his crops, whilst the interest of the local authority is the purification of their sewage. The local authority, as a sanitary authority, must demand a a pure effluent at all times, in winter and in wet seasons as well as in summer and in dry seasons. Between these divided interests of farmer and sanitary authority, the question of purity of effluent may, and in our experience usually does, fall to the ground. Hence, if irrigation is to be adopted, the local authority must provide its own land for the purpose.

Sundry questions at once arise:—

1. Is it practicable to obtain *sufficient* land, and land *properly constituted* as regards general character, level, &c., for irrigation purposes? Let me note that the word "sufficient" is not capable of precise definition. What is sufficient in the case of one kind of land is insufficient in the case of another. What is sufficient land with one kind of engineering treatment, and with one kind of sewage would prove insufficient with another kind of engineering treatment and another kind of sewage.

2. Is this properly constituted land reason-

ably *near* to the town, so that the cost of conveying the sewage to the land will not be excessive, but at the same time reasonably *distant*, so that the town may not derive injury from the nuisance likely (we might almost say certain) at times to result?

3. Is the land of such a level as to necessitate pumping? Is it near a watercourse, canal, railway, &c.?

Let me suppose these questions answered satisfactorily. A very serious further question has now to be considered, viz., Where is the effluent to be discharged?

The importance of the question is this. In all irrigation schemes, of whatever nature, we are dependent for effective purification, on effective land, in effective order. The action of land may become ineffective from circumstances over which we have no control, viz., *frost*, where the ground may become absolutely impenetrable, and *water-logging*, in times of heavy rains, when the sewage is in far greater quantity than normal, and for a time at least more foul than normal, from flushing of the sewers.

Hence, if the outfall is into a river where considerable purity, and unfailing continuity of purity, is demanded, an irrigation scheme is, to say the least, unsafe. If, however, the discharge be into the sea, or into a tidal estuary, or into a stream where the occasional discharge of a little doubtful water is unimportant, an irrigation scheme, pure and simple, may pass muster.

To secure land for a sewage farm (even after the proper land has been found) is not an easy matter. It often means a fancy price. It means, too, a mass of opposition from adjoining property holders, who suddenly discover that all the fields in the vicinity of the land selected is building ground.

I do not mean this as an objection peculiar to land required for irrigation purposes.

Another matter has to be considered. If land be taken on lease for a sewage farm, its renewal may prove difficult. The lease of the Croydon farm expires in 1892.

I will at once admit that my own experience has led me to the opinion that greater advantages result from a combined process of precipitation and irrigation than can be obtained by either method independently, admitting as I do to the full, that a good effluent may be obtained by a precipitation process alone, nearly as good, in fact, as any effluent that can be obtained by irrigation. A precipitation scheme by itself has these two enormous advantages over irrigation, viz. (1) its efficient working is totally independent of weather, and (2) that, if sufficiently large works be erected, any emergency of quantity can be met. Precipitation has had its greatest enemies in its most earnest advocates. Extravagant advantages have been claimed for it. The sludge has been advertised as of enormous manurial value. Patents by the hundred have been taken out. Precipitation advocates have been for the most part advocates of a system in which they are interested. And there is no wonder that distrust in precipitation schemes have arisen, when the *claims* put forth by enthusiasts and patent-mongers have been weighed in the balance against the *facts*, and found wanting.

Supposing, then, we determine on a precipitation process, there arises the first great question, *what precipitant shall be used?* Here two points must be considered. At any rate it will not be disputed:—

1. That, consistently with efficiency and purity of effluent, the chemicals should be cheap.

2. That the smallest quantity of chemicals that experience proves is capable of doing the work properly should be added to the sewage, so as to minimise the quantity of sludge formed.

I am anxious to be in no sense the advocate of any one system of precipitation. I will, admit, however—the process now is not a patent, and if it were I should speak with greater caution—that the A B C turns out the best effluent with which I am acquainted. My own experience leads me to speak very highly indeed of the combined use of lime and sulphate of alumina. The quantity of lime which is to be added first should be such as to render the sewage faintly alkaline. Probably at the rate of from five to seven grains per gallon will be needed for this purpose. It should be added as milk of lime, and should be thoroughly stirred in by means of a paddle-wheel, or other efficient mixer. A flow of a few yards should now be allowed, to permit the aggregation of the precipitate. This having taken place, a solution of crude sulphate of alumina, in the proportion of about five grains of sulphate of alumina, is to be added, and the sewage again actively stirred. In the alkaline condition of the sewage, the alumina will be precipitated, and will then combine with a portion of the organic matter, forming together an insoluble precipitate. Thus treated, the sewage should be allowed to flow into tanks for the precipitated matters to collect.

Let me attempt to indicate the effects of such treatment. A portion of the lime will be at once converted into carbonate of lime, by combining with the carbonic acid present in the sewage, and serve as a weighting material to aid in the deposition of the lighter flocculent materials. This mechanical action of the lime carbonate is of great importance. The flocculent suspended matter is no doubt one of the most important materials to remove, because it is that ingredient of the sewage which readily putrefies, and in this way causes a nuisance. It is, moreover, so light that, unless weighted, it is difficult to precipitate. A second portion of the lime combines with some of the organic matter in solution, producing an insoluble precipitate (of uncertain composition) of a compound of lime and organic matter, the subsidence of which is again assisted by the formation of the carbonate of lime previously described. A third portion of the lime renders the sewage slightly alkaline.

The alumina salt is now to be added. The alumina is precipitated, owing to the alkalinity effected by the slight excess of lime. This alumina combines with some of the organic matter in solution, not precipitated by the action of the lime. The power of alumina in combining with dissolved organic matter, and so removing it from solution, is taken advantage of in many commercial processes.

Respecting the iron salts, one strong objection to their use is, that if the effluent be discharged into a river, the stream is liable to be blackened from the formation of a sulphide of iron, a condition likely to be mistaken by the general public for a sewage deposit. I have therefore, of late, admitting the value of iron compounds as precipitants, hesitated to recommend their use, save under very exceptional circumstances. As regards the use of phosphates as precipitants, the effluent is almost certain to contain some phosphoric acid, which greatly aids the growth of low forms of fungoid growths amongst which may be included the so-called sewage fungus.

It is advisable that the effluent, before its discharge into a stream, be at least neutral, and preferably slightly acid. This condition is easily brought about by the addition of a small quantity of acid to the effluent before its escape.

The effluent, after treatment, will no doubt have a slight odour. This is not, however, a sewage smell. If in this condition of comparative purity—indicated by absence of colour and freedom from suspended matter—it be allowed to flow over and through a small area of land (a loamy sand or gravel by preference) to serve as a chemical filter, high degree of purity may be obtained, and the finer finishing touches of purification effected.

The evils of irrigation under such circumstances do not arise. Such a filtration of the effluent (1) cannot produce a nuisance, because it contains no foul suspended matters to collect on the surface and putrefy; (2) it cannot clog the ground, because the gelatinous and *papier maché* matters in solution have been removed; whilst (3) it has a certain manurial value, the quantity of ammonia in solution being not much less than that of the original sewage.

Again I may quote from Dr. Monro's paper, who, it will be remembered, doubts the advisability of ordinary irrigation as a general process, on account of impervious deposits choking the pores of the land. He says, "The removal of the suspended matter, however, from the sewage, renders irrigation much more practicable. With a clear effluent and a porous soil, the nitrifying power brought into play is enormous, and a moderate area of soil, whether of grass land or arable, can deal with large and almost continuous doses of sewage water." Dr. Monro points out that the presence of objectionable organic matter is as destructive to nitrification as the clogging of the pores of the soil, or a great lowering of temperature.

The Table in p. 1181 will give some idea of the cost of chemical treatment of water-carried sewage.

I may be asked what quantity of land is needed where sewage has been efficiently precipitated. Again the answer will depend on the nature of the land. But if I say an acre to every 5,000 to 7,000 people, I am well within the results of my experience.

Sewage works of the kind I have mentioned can be carried out without the slightest nuisance. The mixing should be done in closed wells. The mixture, as it flows into the tanks, should, if sufficient chemicals have been used, be as free from odour, at the distance of a few feet from the mixer, as common water. The land cannot possibly produce noxious effluvia or poisonous vapours, because the sewage has already been treated with antiseptic precipitants.

Of course all depends on the treatment having been efficient. Success in the treat-

Table showing that the Cost of Chemical Treatment of Water-carried Sewage at the outfall varies according to the foulness of the Sewage operated upon, and that such cost is influenced by the number of Water-closets in use. It will be observed that Water-closets increase the cost of Chemicals at the outfall and lessen the cost of cleansing Privies, Pails, or Middens, but that this increased cost of Chemicals is less than that thrown on the rates by the cleansing and removal of the contents of Privies, Pails, or Middens.

NAME OF PROCESS.	Where used.	Population.	Number of w.c.'s in use.	Number of Privies or Middens, &c., in use.	Quantity of refuse removed yearly from Privies, Middens, &c.	Annual cost of emptying Privies, Middens, &c.	Cost per Million Gallons for Chemicals.	Cost per head per annum for Chemicals.	Cost per head per annum for emptying Privies, &c.	Total cost per head per annum for Chemicals and emptying Privies, &c.
						£	s. d.	d.	d.	d.
Alumina, Iron, &c.	Coventry	42,000	6,000	150	7,000 loads	1,050	19 10	4½	6	10½
Alumina, Iron, &c., Sewage if Dye were absent	Coventry	42,000	6,000	150	7,000 loads	1.050	12 6	3	6	9
Precipitation by Lime and Coke Filtration ...	Bradford	197,000	10 per ct.	90 per ct.	56,200 tons	8,000	11 0	2	9¾	11¾
Lime Process	Leeds	320,000	13,720	43,000	80,000 loads	12,333	10 9	1½	9½	11

From the above Table it will be seen that if the proportion of water-closets at Bradford and Leeds was larger, the cost of chemicals at the outfall must be considerably increased. If on the other hand the proportion of water-closets at Coventry was as low as it is at Bradford and Leeds, the cost of chemicals could be considerably reduced, and would probably not exceed 8s. or 9s. per million gallons. From this it will be seen that alumina treatment, such as that employed at Coventry, is cheaper than lime treatment; and it has already been shown by official investigations, that lime treatment and its modifications are not as efficient as, or equal in sanitary results to, alumina treatment. It is, moreover, still more expensive than is shown in this Table, because of the fact that it produces twice the quantity of sludge as alumina treatment does, the dealing with and disposal of which is a very costly matter, particularly as it is practically useless as a manure, and not so readily saleable as that produced by alumina treatment.

ment of sewage obeys the same laws in this respect as success in anything else.

I am desirous here of pointing out certain details of treatment essential for the success of a precipitation process:—

1. It is necessary that the sewage treated should be *fresh*—by which I mean sewage in which active putrefactive changes have not taken place. Perhaps, speaking generally, the sewage should not be more than 48 hours old for effective precipitation. But it is certain that, with a sewage of not more than 24 hours old, a far better result, with a smaller amount of chemicals, can be obtained. In fixing, however, the time, a certain elasticity must be allowed, an elasticity by way of extension in winter and of compression in summer.

I have said the treatment should be effected *before* active putrefaction commences. In sewage, the decomposition of the different constituents takes places at different times, in some cases the periods of active change being separated by periods of practical rest. Thus a certain alteration in sewage takes place almost immediately. This results (amongst other changes) in the breaking up of the urea, and the formation from it of carbonate of ammonia. It is a rare thing indeed for any sewage, when it reaches the sewage works, to contain more than a trace of urea. No nuisance results from this change of the urea. A considerable interval occurs before any other putrefactive stage occurs, and it is during this interval when the precipitation should be effected. If this period be allowed to pass, increased difficulty in working results.

2. The straining of the sewage before treatment, in order to remove rags, corks, and the various *et ceteras*, such as dead rats, walking sticks, &c., that come down along with the sewage, is advisable but not essential, in order to prevent accumulations on the surface of the tanks. Fixed wire gratings are objectionable, on the ground of their becoming so easily choked. Baldwin Latham's extractor is employed in several places with success.

3. It is essential that sufficient chemicals be employed to effect complete precipitation, disinfection, and deodorisation of the sewage.

No greater mistake can be committed than to starve the chemicals. To this must be attributed many cases where a precipitation process has proved a failure. A local authority will spend a large sum in erecting works, perfect in architectural detail, excellent for sewage treatment, whilst they shirk a small annual payment for the necessary chemicals. I need scarcely point out that efficient works will not purify sewage. They are but the means to an end. It is better to calculate the amount of chemicals to be used on the population than on the quantity of sewage.

4. It is essential that after the chemicals are added, the mixture should be well stirred. The chemist understands the value of the stirring rod in order to effect perfect chemical contact. My own experience is that the chemicals added to sewage are often wasted from insufficient stirring. Not only is it the case that they do not precipitate so much as they might, but the process of flocculation is imperfect, and the difficulty of obtaining a clear effluent correspondingly great.

5. It is essential that there should be sufficient tank accommodation. Let me note sufficiency of tank accommodation is necessary for two reasons—(1) That the precipitate may subside perfectly, and leave a clear colourless effluent. Shallow tanks, with considerable velocity of sewage through them, or insufficient tank accommodation, means imperfect subsidence. Imperfect subsidence means the discharge of a certain quantity of flocculent organic matter in the effluent (the mineral matter being more likely to be deposited from its greater specific gravity), and which flocculent matter is likely to occasion nuisance from its decomposition. The treated sewage should flow through at least two subsiding tanks in series, the first being capable of holding one hour's flow, and the second not less than four hours' flow. The tanks should be at least four feet deep, and the overflow of the defecated sewage should be over a weir, not more than half an inch below the surface. There should be a double set of tanks for successful working.

(2) Sufficiency of tank accommodation is also important, so that the sludge may be frequently removed, otherwise the freshly precipitated sewage may be contaminated by the decomposing materials of a previous precipitation, or a nuisance result from a collection of decomposing matter. Many a good effluent is spoilt by foul materials being allowed to collect in the subsiding tanks. These materials undergo putrefaction, the gases given off contaminating the effluent. The solid matters, becoming specifically lighter than the liquid by the gases of putrefaction developed in and amongst them, rise to the surface, the floating black masses presenting an objectionable appearance, and discharging offensive products into the air. After a time these black masses sink, and thus, by constant commotion of the precipitated matters, a turbid effluent, with a more or less foul smell, results.

6. That the defecated water should flow through a shallow open conduit of not less than a quarter of a mile before being discharged into the stream.

7. The stream into which the effluent is discharged should have a free run, and in volume be not less than eight times the volume of the defœcated sewage.

8. That the tanks themselves should not only be emptied of the sludge, but thoroughly cleansed before being refilled.

The extent of tank accommodation needful will depend a good deal on the dilution of the sewage to be dealt with, either by subsoil or surface waters, or by both, and whether the treatment employed be intermittent or continuous. The following gives the tank capacity provided at certain successful works:—

PRECIPITATION TANK CAPACITY.

Place.	Treatment.	Population.	No. of tanks.	Capacity in gallons.	Gallons per head.
Bradford	Intermittent	200,000	34	612,000	3·06
Coventry	Intermittent and continuous	45,000	8	1,000,000	·22
Hertford	Continuous	7,747	6	318,000	·41
Leyton	Continuous	40,000	4	1,000,000	·25

The most suitable depth for tanks is from 5 to 6 feet.

It may be worth noting the rate at which the precipitated matters deposit when the treatment with lime and sulphate of alumina is efficient, and the sewage collected in tanks of

5 ft. 6 in. The water begins to clear a few minutes after the cessation of agitation. In thirty minutes it clears to a depth of 3 ft., with 8 in. precipitate, while after two hours the precipitate will measure 4½ inches only.

All this accomplished, two questions remain: —(1.) Have you produced such an effluent that it will not pollute the watercourses? (2.) Is not the sludge certain to cause a nuisance?

That a clear, colourless, non-frothing effluent can be produced by mere chemical precipitation, is not a matter of opinion but of fact. That an effluent absolutely without smell can be produced, I doubt. The smell, however, of the effluent from properly treated sewage is not the odour of sewage. I have never, I candidly confess, found an effluent without a certain smell. I have heard a well-known authority ascribe it to the presence of minute traces of essential oils or strong smelling bodies (*e.g.*, onions), difficult of removal by precipitants. If the effluent is to be discharged into the sea, or into a tidal or large river (say 200 or 300 times the volume of the effluent), this odour is absolutely immaterial; but where great purity is required, *e.g.*, when the effluent has to be discharged into a small stream or into a river employed at a short distance from the outfall for drinking purposes, some further treatment is called for.

Such further treatment consists either (1) in the use of artificially prepared filter beds, such as are used for the filtration of water, or (2) by filtration through a small area of land.

Of these two methods, I prefer the latter. After careful consideration, I consider that for this purpose an acre to every 5,000 to 7,000 people (as I have before noted) is abundant. I shall not discuss any question of manurial value, although I may point out that the ammonia of sewage is not appreciably affected by ordinary chemical precipitants.

(2). Is not the sludge an inevitable cause of nuisance? I confess it may be, and often has been. Allowing the sludge to accumulate week after week in the depositing tanks, is not only an evil (as I have pointed out) so far as our endeavours to procure a good effluent is concerned, but an unmitigated nuisance, so far as relates to the sludge. Further, the old method of emptying the sludge into open sludge pits, where the liquid portion was allowed to drain away and to evaporate, has proved a constant cause of just complaint, more especially in warm weather. I am not sure whether the sludge, under these conditions, was not sometimes a greater nuisance after being taken out of the sewage than when left in it. Until lately the difficulty of the disposal of the sludge was one inherent to all precipitation works. Until lately I said—because now the difficulty is overcome.

It is essential, both in the interests of the effluent and of the sludge, that it should be frequently removed from the tanks—I mean that the sludge should be removed before putrefactive decomposition sets in. This frequent removal is necessary (1) so that the effluent may not be polluted, and (2) so that no nuisance may result during the removal of the sludge and the cleansing of the tank. For here I must express a strong opinion that it is not enough merely to empty the tank of sludge, but it is imperative that, after being emptied, and before being refilled, the tank should be well cleansed—in other words, that the matters which stick to the sides of the tank should be completely and efficiently removed to prevent nuisance or fouling by subsequent decomposition.

It would be outside my province to deal with the methods of raising the sludge out of the tanks. This is a purely mechanical question. The sludge is a thick black liquid, which may be pumped out of the tanks or lifted out by bucket pumps into troughs, which serve to convey it wherever it may be wanted.

I am indebted for the following Table to the manager of a sewage works in a residential neighbourhood of a population of 18,000. The process used is lime and sulphate of alumina. The sewage is pressed in one of Johnson's presses:—

Sludge.	Amount per day in tons.	Amount per annum in tons.	Amount per million gallons of sewage in tons.	Amount per million gallons of sewage proper in tons.	Amount per head of population per annum in cwts.	Cost per ton.
Wet........	33·75	12,319	44·53	67·5	13·7	10d.
Pressed	6·04	2,205	8	12	2·45	4s. 7d.

The record of sludge begins on February 16th, 1885, and ends on February 16th, 1886. The wet sludge is got by a series of eighty different actual measurements on various days throughout the year

The pressed sludge is got by keeping a record of the number of times the presses were emptied on every day in the year. A cubic yard of wet sludge is taken as weighing ·98 of a ton, and a cubic yard of pressed sludge as weighing ·75 of a ton (actual determinations).

The following details are taken from Mr. Lacey's Report to the Brentford Local Board, on "The Disposal of Sewage Sludge":—

THE DISPOSAL OF THE SLUDGE AT VARIOUS TOWNS.

I. Left to dry in open pits, and given or sold to farmers.	II. Run on land, or dug in and deposited.	III. Mixed with house refuse and given to farmers, or used on own land.	IV. Partly air dried, and burnt in kiln.	V. Dried, and made into cement.	VI. Pressed in filter presses.	VII. Mixed with house refuse and burnt in destructor.
Atherton, 12,602.* Bacup, 25,034. Burton-on-Trent, 41,500. Chester, 37,000. Ely, 8,171. Derby, 89,690. Leicester, 130,000. Luton, 28,000. Over Darwin, 36,000. Twickenham, 13,200. Taunton.	† Birmingham, 605,000. Redditch, 10,500. Royal Leamington Spa, 24,000. Walthamstow, 30,000. Windsor, 12,500.	Epsom, 8,000. Northampton, 55,000. Wellingborough, 14,000.	Salford, 180,000.	Burnley, 68,000.	‡ Croydon Rural, 25,000. § Coventry, 47,000. ‖ Leyton, 38,000. ¶ Wimbledon, 20,000. ** Chiswick,	Ealing, 18,000.

* The number after each town is the estimated population.

† 479 cubic yards daily; 1 acre of land used weekly; treatment repeated every third year.

‡ Sold at 1s. 6d. per ton.

§ Cost of pressing per ton of cake 2s. 6d. Sold at 2s. 6d. per ton.

‖ Cost of pressing per ton of cake 1s. 8d. Cleared free of cost.

¶ Cost of pressing per ton of cake 3s. 6d. to 3s. 9d. Sold at 1s. per ton.

** Cost of pressing per ton of cake 3s. 4d.

It will be convenient at this point to consider the amount of sludge produced, its value as a manurial agent, and the methods suggested for its disposal.

I.—AMOUNT OF SLUDGE.

The quantity of sludge varies enormously, according to the amount of sewage, and the precipitants employed. Thus, at Coventry the sludge from 1,000,000 gallons is about 12·5 tons, whereas at Birmingham it varies from 25 to 33 tons.

The quantity of sludge produced from a given quantity of sewage will vary according to local circumstances and conditions; such for instance as the character of the soil, the condition of the streets and roads, whether surface water be wholly or in part admitted to or excluded from the sewers, whether manufacturing refuse is included in the sewage to be treated, whether or no the w.c. be in general use, and whether the process of precipitation be complete and efficient or only partial.

In a town where w.c.'s are in general use, where the soil is of gravel and sand, where surface water is partially admitted into the sewers, where there are no manufactories, and where precipitation is well and efficiently done with chemicals of moderate bulk, the proportion of pressed sludge containing 50 per cent. of moisture, may be taken at ·6 (six tenths) of a pound per head per day, or about 2 tons 14 cwt. daily per 10,000 of the population.

The principle is right:—Consistent with efficiency, produce as little sludge as practicable; and this for two reasons—(1), that if it has any value, you secure its maximum value; whilst (2) if it has no value, you have the less to get rid of. Thus with some precipitants you get a large volume of valueless sludge. With sulphate of alumina you get comparatively little sludge, but a material of greater value. Of course it may be argued that the more sludge you obtain, the more perfect has been the removal of the impurities of the sewage. This may or may not be true.

II.—COMPOSITION AND VALUE OF SLUDGE.

I am anxious at once to say that I place no intrinsic value on the sludge whatsoever. An estimate of the value of sludge from different places has been given on high authority, but it is better to regard the sludge as a thing to be got rid of, and as a thing which, to be got rid of, must cost money and may not bring money. The following Table of the analyses of sludge from various places, and by various methods of precipitation, have been given by Dr. Wallace as follows:—

ANALYSES OF SEWAGE SLUDGE (AIR-DRIED).

Name of Town.	Aylesbury.	Birmingham.		Bolton.	Bradford.		Coventry.		Leeds.		Leicester.	Windsor.
Process of Precipitation.	A B C	Lime. 1	2	Lime & Charcoal.	Lime.		Sulphate of Alumina.		Modified A B C	Hanson's process.	Lime.	Hillé's process.
Date.	1879	1879	1879	1879	1876	1879	1877	1879	1876	1876	1879	1877
Water	12·60	12·70	13·16	14·34	8·90	6·92	14·04	10·04	9·56	16·40	11·93	11·76
Organic matter, carbon, &c.	35·60	19·19	20·04	26·18	33·75	34·53	20·58	23·09	20·82	27·92	22·18	12·06
Phosphoric acid	2·11	·40	·72	·62	·80	·73	1·56	2·07	·75	1·21	1·21	·87
Sulphuric acid	2·70	1·45	·35	·61	·64	1·74	1·32	·56	2·15	1·02	·51	·49
Carbonic acid	...	7·62	8·53	8·30	10·53	13·77	6·64	5·71	8·42	13·11	15·25	22·71
Lime	2·18	11·19	12·74	14·50	16·90	20·27	9 16	6·65	9·68	17·51	20·16	31·09
Magnesia	·18	·90	1·37	1·06	1·66	5·07	·86	·61	5 64	7·67	1·48	1·58
Oxide of iron	6·20	2·70	3·20	1·98	2·11	2·01	4·14	2·66	4 61	2·32	2·66	1·68
Alumina	6·75	2·68	2·58	1·97	3·49	3·89	4·13	5·80	7·04	6 30	1·63	2·31
Sand, &c	33·50	41·13	37·93	29·50	21·80	10·23	37·83	42·00	31·60	7·36	22·30	14 16
	101·22	99·96	100·62	100·06	100·58	99·16	100·26	99·16	100·16	100·36	99·31	98·71
Phosphate of lime	4·61	·87	1·57	1·35	1·74	1·59	3·40	4·52	1·39	1·64	2·64	1·90
Nitrogen	1·60	·52	·49	·61	·62	·66	·92	1·27	·66	·70	1·08	·52
Equal to ammonia	1·94	·63	·60	·74	·76	·80	1·11	1 55	·80	·84	1·31	·63
	s.	s. d.	s. d.	s. d.	s. d.	s. d.	s.	s. d.	s. d.	s. d.	s. d.	s. d.
Calculated value per ton	33	10 9	11 5	13 4	15 1	15 4	20	27 2	14 2	17 2	21 7	11 5

A Table by Dr. Voelcker on the estimated and market values of one ton of sludge from places stated is given on p. 1186.

The old system consisted in merely placing the sludge in pits, and allowing it to air-dry, In this condition it was sold or given to the farmers. I may mention here that a sludge containing 90 per cent. of moisture can be reduced to 80 per cent. by forty-eight hours' draining, to 75 per cent. by three days' draining, and to 71 per cent. after a week's draining. After this air drying is comparatively slow, although no doubt the admixture of porous substances would render drying more rapid and more complete.

III.—DISPOSAL OF THE SLUDGE.

1. *Johnson's Process.*—By this process the liquid portion of the sludge is extracted by pressure in a series of compartments. Each compartment is provided with a canvas cloth, which acts as a strainer, and retains the solids as the liquid passes through. The sludge is driven into the compartments by compressed air, 100 to 120 lbs. per square inch, until they can hold no more. On opening the press, a solid cake of compressed sludge is found in each compartment. The cake is compact, easily handled, and practically has no smell. It has a certain manurial value.

It is worth while to consider a few details of pressing. The sludge, as precipitated, contains on an average 90 per cent. of water, whilst the pressed sludge cake contains 50 per cent. By simple air drying, the 50 per cent. of moisture may be reduced to less than 20 per cent. Thus in every ton (2,240 lbs.) of unpressed sludge, 2,016 lbs. is moisture, and 224 lbs. solid matter. After pressure, the 224 lbs. of solid matter holds about 224 lbs. of moisture, the removal of 1,792 lbs., or about 179 gallons, of water having been effected. The time occupied in the compression of 5 tons is about one hour. The sludge cake, according to Monro, contains from 0·6 to 0·9 per cent. of nitrogen, and over 1 per cent. of phosphoric acid. It has been the practice to

Estimated and Market Values of One Ton of Sludge from Places Stated (Voelcker).

	Estimated or theoretical value.*			Practical or market value.†				
	£	s.	d.	s.	d.		s.	d.
1. Bolton sludge (M and C process)	0	9	8½	3	3	to	4	10
2. Bolton sludge, 15 per cent. of moisture	1	1	1	7	0	to	10	6
3. Bradford sludge before lime was added	0	11	0½	3	8	to	5	6
4. Bradford sludge with 15 per cent. of moisture	0	19	3	6	5	to	9	6
5. Bradford sludge after treatment with lime	0	4	8	1	6	to	2	4
6. Bradford sludge with 15 per cent. of moisture	1	0	0½	6	8	to	10	0
7. Aylesbury, A B C sludge	0	8	4½	2	9	to	4	2
8. Aylesbury, A B C sludge with 15 per cent. of moisture	0	16	8½	5	6	to	8	4
9. Coventry sludge of General Sewage Manure Co.	0	16	9½	5	6	to	8	4
11. Rochdale manure	0	15	11½	5	4	to	8	0
12. Halifax manure by Goux's process	0	17	7	5	10	to	8	9

* Calculated on the supposition that phosphate of lime is worth 1d. per lb.; potash 2d., and nitrogen (as ammonia) at 8d.

† By this is implied its value as compared with good farmyard manure, which has a theoretical value of 15s. 7d., its market value being from 5s. to 7s. 6d. per ton.

run back the liquid expressed from the sludge into the sewer, to be re-treated. Professor Dewar and myself have pointed out that this course is unadvisable. The liquid thus expressed is exceedingly foul, although perfectly clear, and does not readily lend itself to ordinary chemical precipitation. I will merely note that it requires separate treatment, and that our experiments indicate that chloride of lime or perchloride of iron in larger amount than is required for ordinary sewage may be rendered effective for the purpose.

The manurial value of the pressed sludge cake from Coventry, Leyton, and West Ham, has been the subject of careful investigation by Dr. Monro, from whom I have abstracted the per-centage details of experiments on the dried sludge given in Table on next column.

Per-centage Details of Experiments on the Dried Sludge.

	Coventry sludge dried. Precipitants, lime and sulphates of alumina and iron (filtration).	Leyton sludge dried. (Precipitants like Coventry).	West Ham sludge dried. (Precipitants, sulphate of alumina and lime.)
Organic matter	26·14	26·08	40 32
Containing nitrogen	1·36	1·35	1·82
Potash	0·30	0·34	0·22
Total P_2O_5	2·43	2·04	2·57
Soluble P_2O_5	1·37	1·69	1·24

The phosphoric acid in sewage sludge is chiefly in combination with alumina. Dr. Monro notes that whilst Coventry sewage contains much manufacturing refuse from dye-works, and West Ham sewage the refuse from industries of a most varied and polluting character, Leyton is a rural and suburban district, having no manufactures of any kind contributing to the sewage.

Dr. Monro has practically tested the agricultural value of these pressed sludge cakes, for the details of which the reader is referred to his original paper. Good crops of swedes were obtained. The three sludges gave almost identical results as regards yield. The following were the results obtained by him with different dressings for comparison:—

Results Per Acre.

	Tons.	Cwt.
1. 10 tons farmyard manure	13	11½
2. 4 cwt. superphosphate	11	2¼
3. 5 tons Leyton sludge	10	4
4. 5 tons farmyard manure	10	1½
5. 5 tons West Ham sludge	9	8½
6. 5 tons Coventry sludge	9	6½
7. 2 cwt. superphosphate with 2 cwt. of nitrate	9	5¼
8. 2 cwt. superphosphate	9	4¼
9. 2 cwt. coprolite	8	15½
10. 4 cwt. coprolite	7	10
11. Unmanured	5	18

From these details it is evident that the air-dried filter-pressed cake has a certain manurial value—at any rate, about equal to farmyard manure—which possibly, considering how easily it may be stored without causing a nuisance, may be worthy of being considered more fully than it has at present. It is worth noting that, although the newly pressed cake is richer in nitrogen than farmyard manure, and contains more than double the amount of phosphoric acid, still that the manurial value is not greater, weight for weight. This Dr. Monro explains by differences of physical condition, viz., the loose texture of farmyard manure compared with the compact condition of the sludge cake; the physical state of the one being as favourable to rapid oxidation and disintegration, as that of the other is unfavourable. To overcome this difficulty, Dr. Monro suggests the reduction of the cake to a fine state of subdivision.

The cost of procuring the sludge is stated by Mr. Hutchinson (to whose excellent paper I must refer) as from 2s. to 2s. 6d. per ton at Coventry. I have no records as to what the further cost of grinding would involve.

The Johnson process is at work at Croydon Rural, High Wycombe, Coventry, Leyton, Blackburn, and Aylesbury.

(2.) *Major-General Scott's Process.*—This is adopted at Burnley. The lime precipitated sludge (*i.e.*, lime and organic matter) is drained until it contains about 65 per cent. of moisture. The sludge at this stage is tested as to the amount of lime present, more being added if necessary. The mass is now dried by heat, and finally burnt in kilns. The residual clinker is ground, and used as an hydraulic cement (Portland cement). The cement is said to have a tensile strength of 350 lbs. per square inch after immersion in water for seven days, and to be worth 35s. per ton.

It is evident that the composition of sewage sludge varies not only in different towns, but in the same town at different times. It is not quite clear how far this process can be worked so as to secure that which engineers know to be so important, viz., a cement of constant character. (See paper by Granville Cole, Ph.D., Society of Arts Conference, 1879, p. 137.)

The cost of drying is 7s. per ton. The coke employed for burning averages 1s. 4d. per ton, and the labour, &c., 15s. per ton.

Major Scott has suggested that in the case of the London sewage both a manure and a cement might be prepared.

In the *Journal of the Society of Arts*, November 28, 1879, he suggests, in the treatment of sewage, that the primary separation of the coarser mineral suspended matter should be effected in a first tank, a sufficient period of rest being afterwards allowed for the subsidence (not the artificial precipitation) of the lighter suspended matters in a second tank. The sludge of this second tank (*i.e.*, after the watery portion has been drawn off) is to be treated with about two-thirds its weight of milk of lime, sufficient superphosphate being afterwards added nearly to neutralise the lime. (The superphosphate is to be prepared by mixing 20 cwt. of Cambridge coprolites with 17 cwt. of brown sulphuric acid, sufficient water being added to render the mixture almost fluid). By this treatment the mixture (he states) becomes surprisingly inodorous, and dries with rapidity. The cost of chemicals he values at 16s. 6d. per ton of prepared manure, its removal from the tanks and subsequent drying being 3s. 6d. He considers it worth £3 10s. per ton. The sewage, or liquid portion of the second tank, from which the organic matter has been recovered, is then to be treated with lime, and the precipitate thus obtained made into a cement.

Major Scott seems to have overlooked the difficulty of effecting precipitation of the suspended matters of sewage (such as he is desirous of obtaining in the second tank) without the use of precipitants. Further, a limed sludge, when dried, is certain to lose ammonia, in other words, is certain to lose manurial value.

The deposit in the first tank Major Scott proposed should be burnt in a destructor with waste cinders, and be used to reclaim a portion of the marshes. At any rate (he justly considers) it ought not to be allowed to pass into the river.

(3.) *Destructor.*—The destructor has been carried to its greatest state of perfection at Ealing, under the ingenious and careful management of Mr. Charles Jones. In this case, however, the ashes of the district are mixed with the sludge. The chemicals used for precipitation are 11·5 grains of clay and about 10 grains of lime per gallon, a little iron and alumina being also used. The sewage treated comes from a population of about 18,000, and is equal to 600,000 gallons daily. About 157 cubic yards of sludge are obtained per week. This is mixed with about 100 cubic yards of ashes and house refuse. Before the mass is burnt in the destructor, about 25 per cent. of the liquid portion is allowed to drain away.

It may be advisable here to note the difficulties that have been met with generally in the use of destructors:—

1. An escape of vapours that prove more or less offensive at a considerable distance from the shaft. This depends on the materials having undergone incomplete burning, in other words, that the materials in the destructor have been subjected to destructive distillation (in which case the products, consisting of

various empyreumatic vapours, are offensive), rather than combustion, in which case the products would be simply water and carbonic acid, and inoffensive. No doubt, until lately, the escape of unburnt and partially burnt vapours, a very small quantity of which sufficed to cause a nuisance, have proved a serious objection to the use of destructors.

2. The escape from the shaft of unburnt or partially charred paper, fine sand, &c., at certain stages of the process.

I do not hesitate to say that both of these difficulties are met in Jones' destructor. This has been done by mixing the sludge with the house ashes, thus assisting effective combustion. Mr. Jones lays down that every town supplies sufficient house refuse to burn its sludge. The main point, however, on which he relies, is the construction of a muffle furnace (a fume destroyer, as he calls it) between the furnace and the main shaft. As a result, not only is a greatly increased draught secured, but the combustion of unburnt vapours discharged from the furnace in which the sludge is placed is secured. I may add that Mr. Jones informs me that the muffle furnace is kept going at a cost of 1s. 6d. per day, but that this, in addition, gives 10 lbs. of steam for engine purposes. He obtains, as a residuum from the furnace, 25 per cent. of hard clinker, which is utilised in various ways, viz., for artificial stone, road-making, &c.

Various suggestions for what may be called fortifying the sludge have been suggested. Thus, Colonel Jones, of Wrexham, after drying the sludge to 20 per cent. of moisture, adds to every 12 parts 7 parts of raw bone meal and one part of sulphate of ammonia.

I do not propose discussing other suggestions for the disposal of sludge, such as the separation of the water by centrifugal machines—converting the sludge into a fuel by admixture with other waste products—its conversion into a combustible gas—making it into bricks, &c. (Monson). These suggestions are scarcely practical.

The question of cost must be considered in conjunction with (1) the quantity of the sewage, (2) the quality of the sewage (that is, the nature of the sewage other than mere excreta), (3) the flow per head, and (4) the standard of excellence required.

As regards quantity, I wish to say that you cannot apply the cost of treating small volumes of sewage to the cost of treating large volumes, the treatment of the former being more easily effected than the latter.

Prices of Chemicals.

Green copperas or proto-sulphate of iron can be obtained for about 20s. per ton.

Lime can be obtained from 10s. to 15s. per ton.

Suphate of aluminia can be obtained from 46s. 6d. per ton, as per following analysis :—

Moisture	5·94
Crystalised sulphate of alumina	77·44
,, sulphate of iron	4·00
Sulphates of alkalies and sulphuric acid	6·82
Insoluble iron and alumina	5·80
	100·00

The annual cost of thoroughly and efficiently treating the sewage of Coventry, pressing the whole of the sludge, &c., exclusive of interest on plant, land and depreciation—the population contributing being 45,000 persons, and the sewage containing large quantities of dye and manufacturing refuse—is £2,800 per annum, an amount equal to 1s. 3d. per head.

The cost at Hertford, where the sludge is not pressed, and manufacturing refuse is absent, with a population of 7,747, is £570 per annum, equal to 1s. 5½d. per head.

A few words only on the analysis of sewage. No single analysis of a sewage effluent is satisfactory as proof of good or of inefficient working. Knowing as we do that sewage varies from hour to hour, no accurate conclusion can be drawn as to the composition of the raw sewage or of the effluent, except by collecting half hourly, or at least hourly, samples during one entire period of twenty-four hours, and the various samples mixed in the proportion of the fluid. The analysis of a sample of raw sewage and of an effluent taken about the same time are not comparable, because the passage of the sewage through the tanks is commonly the work of some hours. Supposing, for example, I collect a sample of twelve o'clock sewage and a sample of effluent at the same time, the twelve o'clock sewage may be the very strongest sewage of the day, whilst the effluent sample is the effluent of the very weakest sewage. Precisely the opposite condition may occur, viz., that I may compare the effluent of the strongest sewage with the weakest raw sewage delivered.

Further, in all cases where analyses are made for test purposes, the weather should be noted, the rainfall and the flow being compared with the average flow. For accurate purposes a normal condition of flow should be selected, and comparison made between the average of twenty-four hours' sewage and twenty-four hours' effluent.

As regards the analysis of sewage, it is advisable to estimate the quantity of the matters in suspension, and in these the amount of mineral and organic (with volatile) matters. In addition to this, I have of late adopted the system of estimating the organic carbon and nitrogen, and the oxygen required to oxidise the organic matter in the effluent without removing the suspended matter. Seeing that the real issue is the condition of the effluent, I consider this method preferable to an analysis of the clear effluent after the removal of the suspended matter.

I propose the following form as one which conveys the best information that chemistry can afford as to the chemical composition of a sewage and of an effluent:—

The results are stated in grains per imperial gallon of 70,000 grains.

Matters in Suspension—Total ....
  (α) Organic and volatile ..
  (β) Mineral ....

The following details have been obtained from the effluent without the removal of the suspended matters:—

Total solids (suspended and dissolved)
Ammonia ....
Chlorine ....
  = Chloride of sodium ......
Nitrogen (as nitrites and nitrates) ....
Oxygen required to oxidise organic matter
Organic carbon ....
Organic nitrogen ....

To get rid of excretal filth with the least possible delay is no doubt the teaching of sanitary science. The advocates of the water-closet urge that water as a vehicle to carry the refuse commends itself to us on the ground of convenience, cleanliness and cheapness. They would compare, with plausible argument, the natural power of gravitation (such as is made use of in the water-closet) with an organisation of men and carts (such as is required by the dry earth system). The advantages, at first sight, seem all on one side. Facts, however, point in an opposite direction. Dilution with water is the best known method of rendering practically useless whatever is valuable in sewage—indeed, worse than useless, an ungovernable nuisance. The excreta of animals are no doubt intended for the food of plants, and for our use through their intervention. Of course, do what we will, nature will assert herself and her plans. But nature is embarrassed by our meddlesomeness. The nutritive food of the plant we drown in water, our ingenuity failing when we attempt to deal with the filthy mixture. We cannot utilise it, unless we abandon all sanitary precautions; it pollutes our air, renders our ground a stinking morass, and defiles our watercourses. Thirty gallons of water daily per head is brought to us who live in London, from pure sources, at great cost, and with great engineering skill; filtered, often refiltered, with extraordinary care; stored with scrupulous anxiety; analysed by one chemist after another. It is, however, a striking fact that only 1-90th part of the entire water supply is used for drinking purposes, a large quantity being destined to become the diluent of our sewage, to perplex us by its quantity, to bother us by its uselessness, and to steal our health by the perpetual nuisance it occasions.

I desire to acknowledge my indebtedness in the preparation of this paper to numerous friends. Amongst others I cannot forbear mentioning Professor Dewar, Mr. Hawksley, Mr. Mansergh, and Mr. Melliss.

Miscellaneous.

GERMAN TRADE IN THE LEVANT.

In a recent report to the Italian Minister of Foreign Affairs on trade with the Levant, the supremacy of the German traders over those of other nations in the East, is attributed to their being the most expert and enterprising. In the first place they are the first in the field to offer their goods, obtaining where it is possible every facility as regards means and cost of transport, and even taking their goods in many cases to the place of consumption. The numerous German houses that have been established of late years, and which are constantly increasing, are exceedingly active in making the goods of their country known in the Levant; they give most reliable and detailed information to their correspondents at home, and represent German firms on most moderate terms; and whilst a host of commercial travellers of the same nationality are busily engaged in obtaining orders in every little town and village, the numerous commercial firms established at all the ports and large towns are looking after the interests of the houses that they represent. The German firms established in the Levant, endeavour and, generally speaking, manage to keep the trade entirely in the hands of their countrymen, to the exclusion of firms of every other nationality, and especially the native ones, because in the case of complaints and difficulties arising with the local authorities, German political pressure and influence can be brought to bear in order to get the question settled in their own favour and without delay.

Another cause which is said also to have contributed greatly to the success of German traders, is the defective system adopted by the English and French merchants, and which their energetic rivals know so well how to avoid. The English and French, as a rule, adhere to their ancient customs, dealing only with the large Levantine traders in the principal towns. The German commercial traveller, on the other hand, may be found in the most remote and out-of-the-way places, pushing his goods right and left, calling upon and driving bargains with the smallest shopkeeper, and rarely going away without having obtained an order. It often happens that several firms engage the same person, so that it is not unusual to meet a traveller offering stuffs, paper, spectacles, perfumery, watches, patent medicines, &c., in the same little town. In this way he makes a large connection which is carefully kept up by the local German agents, who are especially chosen for that purpose. In their periodical visits the German commercial travellers take every opportunity of examining whatever articles of French or English make that may happen to be in the shops of their clients, and at their next visit almost invariably are in a position to offer similar goods, but of German manufacture, which if not equal in quality, at all events closely resemble the former, and always at lower prices. The consequence is, that the natives are induced by their cheapness to prefer articles of German make, which are gradually driving all others out of the market. Another advantage which many of the German commercial travellers have over the other nations is in being able to speak the Greek and Turkish languages. The German Government has established at Constantinople a college, which is frequented both by Christians and Mussulmans, and the use of the German language is rapidly being introduced into the schools of the Levant, and at a pace with the invasion of Germans into both civil and military employment.

Obituary.

Rear-Admiral Bedford Clapperton Trevelyan Pim, R.N., died, at Deal, last week, in his sixty-first year. He was born on the 12th of June, 1826. In 1842, Mr. Pim entered the Royal Navy, and in 1845 was appointed to her Majesty's ship *Herald*, then ordered on a scientific voyage round the world. His next expedition was to Behring Straits, attached to her Majesty's ship *Herald*, in search of the missing ships of Sir John Franklin. On his return to England, in 1851, he was promoted to the rank of Lieutenant. He served in the Arctic Expedition sent out under Sir E. Belcher in 1852. In March of the following year, while attached to her Majesty's ship *Resolute*, he made a journey of twenty-eight days across the ice, and rescued the crew of her Majesty's ship *Investigator*, commanded by Captain M'Clure—a vessel which was about to be abandoned, having been icebound for three years. In 1857, he was appointed to the command of her Majesty's gunboat *Banterer*, ordered to China on the breaking out of hostilities between England and that country. Here he was so severely wounded as to be invalided home. In 1858, he received the rank of Commander. In the following year he left the service. He subsequently became Post-Captain, and obtained his Flag rank in 1885. He twice contested Totnes unsuccessfully in the Conservative interest. In 1874, he was returned for Gravesend. He became a member of the Society of Arts in 1863. In January, 1875, he read a paper on "The Mercantile Marine of Great Britain," which led to a discussion extending over four evenings. In 1879, he read a paper on the "Panama Canal."

General Notes.

Population of Italy.—The population of Italy has doubled during the last century. On the 31st December, 1885, it amounted to 29,699,781, showing an increase of 338,749 on the population of the previous year, which amounted to 29,361,032. The population of Italy, previous to the constitution of the kingdom, was—

1770	14,689,317
1800	17,237,421
1848	23,617.153
1858	24,857,417

Since the constitution of the kingdom of Italy—

1861	25,016,801
1871	26,801,154
1875	27,482,174
1880	28,524,999
1883	29,010,652
1884	29,361,032
1885	29,699,781

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Proceedings of the Society.

CANTOR LECTURES.

FRICTION.

By Professor H. S. Hele-Shaw.

Lecture I.—Delivered January 11, 1886.

The Friction of Solids.

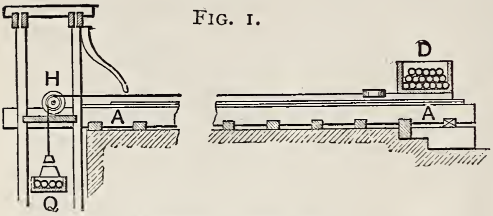
If we place the surfaces of two bodies in contact, and press them together, we are conscious of a resistance opposing any attempt to move one over the other. This resistance is reduced by diminishing the roughness of the surfaces and decreasing the pressure, but it can never be caused to disappear, no matter how smooth the bodies are made, or however small the force acting between them. This opposing force is called the *resistance of friction.* Not only does a resistance to relative motion occur between the external surfaces of bodies, but between the internal parts of both solids and fluids, and to this resistance the term "friction" is likewise applied.

We shall hereafter have occasion to carefully discuss whether or not the use of the same word for the phenomena of this kind both for solids and fluids is advisable; but it is evident that, taking the word in its present general sense, the subject of friction covers a very wide field, and has an importance which, whether we regard it from a purely practical point of view or in its scientific aspect, is not easy to realise. The object of this course of lectures is to gather together the facts concerning the nature and application of friction which have gradually become known, and present them in such a manner as to enable as clear a grasp as possible of the whole subject to be obtained. It will be impossible, in the four lectures before us, to give more than an outline of the above facts, but my aim throughout will be to adopt a method of treatment at once elementary and complete, and to bring forward such data and experiments as may best illustrate the general principles of the subject. In the present lecture we shall study the friction of solid bodies; in the next the nature and laws of fluid friction, the term "fluid" including both liquids and gases. The third lecture will deal with the mechanical applications of friction, while in the fourth we shall regard friction from the opposite point of view, viz., as a resisting force which is always being brought into action, and which the practical man, and particularly the engineer, finds it necessary to take into consideration in all mechanical problems. In short, while the two first lectures deal with the nature and laws of friction, the two last will respectively treat of it in its useful and prejudicial aspects.

The Friction of Solids.

About 100 years ago the celebrated French philosopher, Coulomb, enunciated certain general truths as the result of his own investigations, and those of previous workers on the subject of friction. He stated that, with certain exceptions, the resistance of friction of solid bodies (1) varied directly as the pressure between the surfaces in contact, (2) that it was independent of the extent of those surfaces, and (3) that it was independent of the velocity of their relative motion over each other. These truths, which have ever since been known as the laws of friction, were examined by means of a very large number of experiments, conducted at the expense of the French Government by General Morin, who confirmed in the main their accuracy for the comparatively limited range over which he extended his observations. Coulomb's laws, which are capable of expression in a very simple mathematical form, and hence are easily employed in numerical calculations, have in consequence been, until a recent period, adopted universally and relied on implicitly, not only within the limits of Morin's experiments, but beyond them. For this reason, and also in order to enable the modifications which are the result of more recent researches to be afterwards better understood, it will be advisable to study them rather carefully, and especially their mathematical form of expression. We shall best be able to do this by studying Morin's method of experiment, which will be made clear by the help of the rough model of his apparatus before you. That apparatus (Fig. 1) consisted of a loaded box, D, resting on a slider, and pulled along by a smaller loaded box, Q, which was suspended by a cord passing over a pulley, H. The slide on which the slider rested was supported by beams A A (only a short length being shown in the figure), and both slider and slide could, after each set of experiments, be replaced by others of different material.

Fig. 1.



Morin's Apparatus.

Suppose the weight of the suspended box so adjusted as to just pull the larger one along, any increase in the weight of the latter would prevent motion taking place. Morin found that, if this weight were doubled, that of the suspended box must also be doubled for motion to take place; if it were trebled, the other must also be made three times as great, and so on. In short, for every pair of surfaces the force of friction (which, if we suppose the pulley to be frictionless, was directly measured by the weight of the smaller box) varied directly as the pressure between the surfaces (as measured by the weight of the larger box).

The truth of this can be demonstrated by the model before you. With a slider of pine on a pine slide—

A weight of 56 lbs. requires 19 lbs. to draw it along.
,, 28 lbs. ,, $9\frac{1}{2}$ lbs. ,, ,,
,, 14 lbs. ,, $4\frac{3}{4}$ lbs. ,, ,,

If the two surfaces were changed for another pair, the same fact was found to hold, although the proportion between the weights had a different value. This we can also verify by changing the surfaces of pine for cast-iron. The result now is that, roughly:—

A weight of 56 lbs. requires 8 lbs. to draw it along.
,, 28 lbs. ,, 4 lbs. ,, ,,
,, 14 lbs. ,, 2 lbs. ,, ,,

It is evident that, if the first law be true, there is for one pair of surfaces always a definite numerical relation between the resistance of friction (represented by the weight over the pulley) and the reaction of the surfaces (represented by the weight on the slider). The number expressing the ratio of these two quantities is called the "co-efficient of friction." Thus from our experiments.

The co-efficient of friction of pine on pine

$$= \frac{19}{56} = \frac{\text{[illegible]}}{28} = \frac{}{14} = \cdot339.$$

The co-efficient of friction of the cast-iron on cast-iron

$$= \frac{8}{56} = \frac{4}{28} = \frac{2}{14} = \cdot143.$$

It is convenient to have a symbol to represent the co-efficient of friction, and the symbol which has been appropriated for the purpose is the Greek letter μ. Also let

F = the resistance of friction.
R = the reaction between the surfaces.

Then for pine on pine—

$$\frac{F}{R} = \mu \quad \cdot339.$$

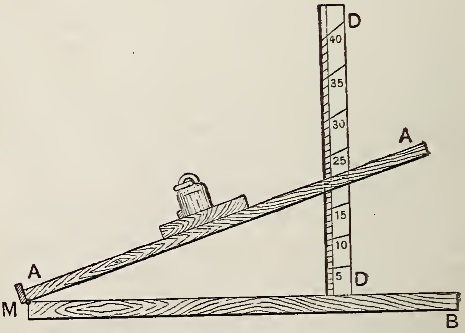
For cast iron on cast iron—

$$\frac{F}{R} = \mu = \cdot143.$$

The value of μ has been determined for all solid bodies which are likely to be used in frictional contact, and tables of results are to be found in various works on mechanical science.

Besides the method above described, there are two other ways in which the first statement of Coulomb may be verified. The former of these ways can be illustrated by means of the simple apparatus before you. In this apparatus (Fig. 2) the pine slide, A A is, hinged at one end, M, to the base, B, and by gradually raising the other end, a position is reached at which the weight upon it moves down at a uniform rate under the action of gravity which is then just sufficient to overcome the resistance of friction.

Fig. 2.



Apparatus for Measuring the Angle of Friction.

The inclination of the slide to the horizon can be observed by means of a vertical scale, D D, and if we replace the weight by others in succession, we find that as long as the surfaces are the same, the angle (ϕ) at which sliding takes place is always the same (being in this case equal to 18° 45′). This fact proves the truth of the first law of friction, for suppose G (Fig. 3) to be the centre of gravity of the weight and slider, and Ga_1, Ga_2, Ga_3, to represent various weights, then Gb_1, Gb_2, Gb_3, represent the corresponding reactions between the surfaces in contact, and (when the slider moves down at uniform speed) a_1b_1, a_2b_2, a_3b_3, the corresponding frictional resistances. From the figure it is clear that—

$$\frac{\text{Resistance of friction}}{\text{Reaction between surfaces}} = \frac{F}{R} = \frac{a_1b_1}{Gb_1} = \frac{a_2b_2}{Gb_2} = \frac{a_3b_3}{Gb_3}$$

but as we have already seen, the first law really asserts the ratio between F and R to be constant, and so the truth of that law is again verified.

FIG. 3.

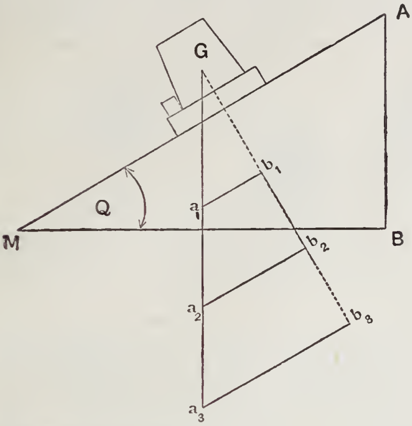


DIAGRAM FOR PROOF OF FIRST LAW OF FRICTION.

The angle at which sliding takes place, for any pair of surfaces, is called the "angle of friction" for those surfaces, and is connected in the following simple way with the co-efficient of friction. Since each of the triangles Ga_1b_1, Ga_2b_2, Ga_3b_3, is similar to the triangle A M B, it follows that—

$$\frac{a_1b_1}{Gb_1} = \frac{a_2b_2}{Gb_2} = \frac{a_3b_3}{Gb_3} = \frac{AB}{MB} = \frac{F}{R}$$

$$\text{Also } \frac{AB}{MB} = \tan\phi = \tan \text{ (angle of friction)}$$

$$\text{and } \tan\phi = \frac{F}{R} = \mu.$$

Thus in the case of pine upon pine—

$$\phi = 18^\circ\ 45'$$
$$\text{and } \tan 18^\circ\ 45' = \cdot339,$$

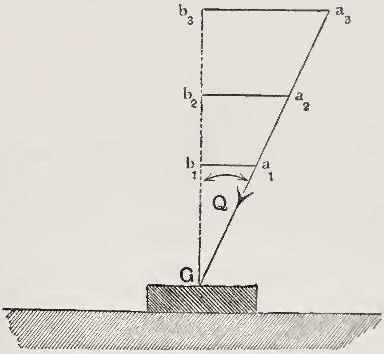
which is the co-efficient of friction for those surfaces.

Lastly, there is yet one other way of verifying the first law. Suppose a force to act at first vertically upon the slider, and its direction to be gradually inclined. Then at a certain inclination with the vertical the slider will just move along the slide. This angle is the same as long as the surfaces are the same, whatever be the force acting, and is in fact the angle of friction. Fig. 4, shows why this must be the case if the first law be true, for if a_1G, a_2G, a_3G, represent in magnitude and direction the successive values of forces acting, then—

$$\frac{E}{R} = \frac{a_1b_1}{b_1G} = \frac{a_2b_2}{b_2G} = \frac{a_3b_3}{b_3G} = \tan\phi$$

that is, the frictional resistance varies with the reaction between the surfaces.

FIG. 4.

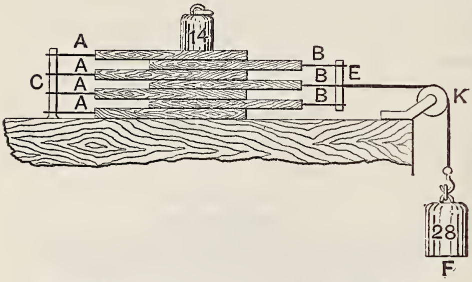


THE FIRST LAW OF FRICTION.

The second statement of Coulomb, which is often called the second law of friction, really follows directly from the first. To make this clear, suppose the original area of the surface of the slider to be four feet. Let it be altered so as to have eight feet in contact with the slide. Then the weight of the box D (Fig. 1) being unaltered, it is clear that each four feet of surface in contact now only sustains half the load in the box, that is to say, is subject to half the pressure it previously had, therefore for that portion the resistance of friction will be only half as much as before, and for the whole surface it will be twice as great as this, or equal to the original amount. By a similar method of reasoning, it may be proved that the weight in the smaller box would remain unchanged, whatever change were made in the extent of the surfaces in contact, which proves the truth generally of Coulomb's statement that the resistance of friction is independent of the extent of those surfaces. We can readily verify this with both models we have used (Figs. 1 and 2) with sliders of various sizes.

It is here necessary to point out an important qualification that must be understood as attached to the above statement, which only holds true as long as the surfaces in question form one pair, the different parts of which are rigidly connected with each other so as to *distribute* the reaction. This may be easily shown by means of a piece of apparatus Fig. 5), consisting of four flat pieces of wood (A A A A) alternating with three other similar pieces (B B B), the former being fastened to an upright pillar, C, the latter to a rod, E, which rod E sustains the pull of a weight suspended over the pulley K. The result of this arrangement is, that there are six pairs of surfaces in contact. Hence, instead of the friction remaining independent of the extent of the surfaces, it is increased by each additional surface just as if a separate weight equal to the original one had been added. In the case before you, the weight of 14 lbs. resting on the slider would, for one surface only, require $4\frac{3}{4}$ lbs. to overcome the friction, whereas, six times that amount, or rather more than 28 lbs., is actually required.

Fig. 5.



The Transmission of Surface Pressure.

The simple explanation of this is that pressure, instead of being distributed by the additional surface, is *transmitted* from one to the other. This device for increasing the resistance of friction by increasing the surfaces of contact has, as we shall hereafter see, been directly employed in a very interesting nvention, and is one of many examples in which the results seem to contradict the second law of friction, but which are quite in accordance with it, in its qualified form of statement. This principle of transmitting force to increase friction is used in many cases, and is, for instance, of universal application in the employment of cords and bands for transmitting power over pulleys.

The third statement of Coulomb was verified by Morin in two ways. In one of them the two weights (Fig. 1) were carefully adjusted so that the smaller was just sufficient to draw the larger one along. Then it was found that whatever was the initial velocity of motion this velocity was uniformly maintained. This experiment we can repeat with our own models, and it is clear that the law is, as far as can be observed, correct, at any rate for the distance which the slide can move.

In the second method, adopted by Morin, a greater weight was used in the small box than was sufficient to overcome the resistance of friction, the effect being to cause the rate of motion to increase. The rate of increase was carefully recorded, and was found always to correspond exactly to that due to the surplus weight in the suspended box. That is to say, at whatever speed the surfaces moved over each other, the resistance of friction only required a constant weight to overcome it, the excess of weight merely acting to further increase the velocity.

The simple laws of friction which we have now studied can readily be expressed in a mathematical form. We have seen that the first law is equivalent to the statement that the ratio of frictional resistance to the corresponding reaction between the surfaces is constant, and that the second law is included in the first. Now the third law merely states that the velocity of motion has no effect on the resistance of friction, and therefore the velocity will not occur in any mathematical expression of the laws. Thus all three laws are completely expressed by the simple equation :—

$$\frac{\mathrm{F}}{\mathrm{R}} = \mu$$

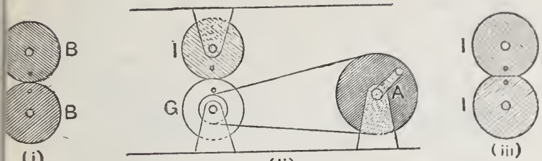
or—Resistance of friction $= \mu \times \mathrm{R}$.

This expression is so simple and so convenient to use, that it is not surprising that it has been universally adopted. We shall, however, see that, although the laws which it represents are approximately true within certain limits for dry surfaces, they are correct neither as regards velocity or pressure for the range of values commonly occurring in practice, and are altogether incorrect if applied in cases where lubricants are used.

Hitherto we have considered only the case of direct sliding. We now come to the study of the rolling of surfaces over each other, the cause of the resistance to which it is not so easy to understand.

By means of an arrangement which is fitted into the lantern, we can examine the rolling of two surfaces upon each other from the enlarged image on the screen.

Fig. 6.



(i) (ii) (iii)

Lantern Apparatus for Investigating Rolling Friction.

Fig. 6 shows three pairs of discs, each pair of which is actuated by an arrangement similar to that shown in (ii), the wheel A driving the lower disk by means of a fine endless band, the lower disk in turn imparting motion to the upper one by the frictional contact of their edges. Taking first the pair of brass discs, B B (i), it is seen that although they are pressed together with some appreciable force by means of a spring, the extent of contact is extremely small; indeed, they scarcely seem to touch at all, yet when the lower one is turned, the upper one is carried round, and no apparent slipping takes place. This is made evident by the aid of two small holes drilled in the discs, which, being placed initially so as to be opposite each other, are seen to occupy the same relative position after every revolution, even when the speed of rotation is considerably increased. If we now examine the rolling of the two india-rubber wheels, I I (iii), we find that the extension of the edges under the pressure causes a greater area of contact, but that the force required to rotate them is not increased so much as might be expected. The fact is that being equally soft the extension of their peripheries is equal, and thus there is no appreciable slipping of their surfaces upon each other, which is evident from several observations of the relative positions of two holes made for the same purpose as those in the brass discs. Lastly, let us examine the rolling of a hard surface and a soft surface upon each other, this we can do by the glass wheel, G, Fig. 6 (ii), with roughened edge working on an india-rubber wheel, I. Here we can see that the india-rubber edge is extended so that the area of contact is, as in the foregoing case, considerable; the result of this extension is to cause the rolling periphery of the india-rubber to be greater than that of the glass, and if we now compare the relative position of the spots of light passing through the holes in the two discs, we see that the india-rubber disc, being practically larger than the glass one, turns at a slower rate. The resistance to turning, which is appreciably greater than in the first of the two foregoing cases, and as far as can be judged, if anything, greater than in the second, is accounted for by the fact that the surface of the india-rubber must, in extending, slip over the harder surface in contact with it. This is the cause of what Prof. Osborne Reynolds has rightly insisted should be called rolling friction (the word friction being derived from a Latin word signifying "to rub"), and he has explained the action, which takes place in a very interesting way.

Let Fig. 7 represent a block of elastic material held between two surfaces which are capable of being pressed together. Suppose first that there is no frictional resistance between the block and the surfaces. Then the result of compressing the block will be simply to cause it to take the form shown in Fig. 8, the series of vertical lines being shortened and moved further apart. Suppose, however, that there is some appreciable friction, then the lines originally vertical will be caused to curve to a greater or less extent, as shown in Figs. 9 and 10. Fig. 9 represents the case where the frictional resistance is small. Here the effect of the compression is to cause all the surface to slide, except that portion between the two darkened lines (originally vertical) on either side of the centre line. Fig. 10 represents a

Fig. 7.

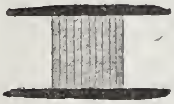


Fig. 8.

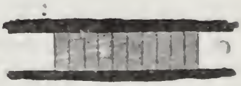


Fig. 9.

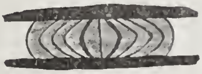
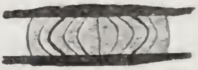


Fig. 10.

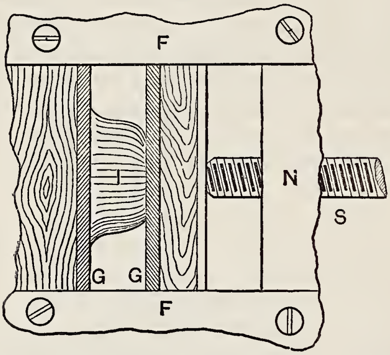


The Fricton of Surfaces in Extending and Contracting.

case where the friction between the surfaces and the block is greater than in the former case. Here slipping takes place only at the third lines (shown thicker than the rest in the figure) on either side of the centre line.

We can examine different cases of frictional resistance by means of an arrangement which is now projected on the screen. Fig. 11 represents a portion of a frame (F F), in which a screw (S) works in a nut (N), and enables a pressure to be brought upon a sliding piece with a thick glass face (G) between which and another thick glass plate G (fixed to the frame) a block of india-rubber (I) is placed. The action which goes on can thus be carefully studied, not only for the glass surfaces but for surfaces of any other kind which can be inserted between the glass and the india-rubber. Fig. 11 shows the result of having a dry clean surface of glass on the moving side while the surface of glass on the fixed side is slightly oiled. Time does not permit me to dwell on the various results I have obtained with different surfaces, particularly in the form of the outline of the block under pressure, but they do not appear to be included under what Professor Reynolds has mentioned in his paper.

Fig. 11.



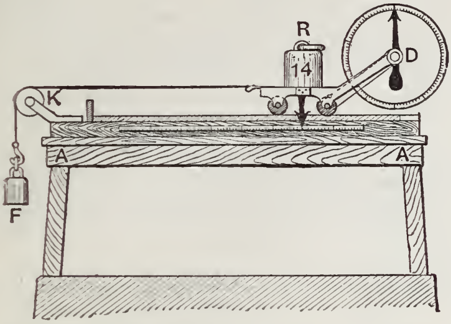
Lantern Apparatus for Examining Surface Resistance to Extension and Contraction.

Now, the work done in overcoming the resistance to sliding cannot be restored when the surfaces are again separated. To realise this important point, it must be remembered that the lateral extension would be greater but for the frictional resistance to sliding, and the work now done in friction would otherwise store up an equivalent amount of energy to be given up by the return of the block to its original form. In the same way the block, in returning to its original shape, has a certain portion of its power of restitution absorbed in overcoming frictional resistance. Thus there is a loss of energy both in the extension of the surfaces and in their compression. It is evidently a matter of the greatest consequence to see whether this takes place in the rolling of two surfaces on each other. We may investigate this point in the following way:—Make two marks tolerably close to each other on the rim of a soft disc rolling on a hard one (*e.g.*, the india-rubber on the glass disc, Fig. 6, ii), and take the distance apart of these with a fine pair of compasses or dividers. Keep the one leg of the dividers upon one point and roll the discs so as to bring it into the line of contact, noting meanwhile the change of distance of the other point from it. Then it will be found that, both on approach and recession to the line of contact, the sliding friction acts in the opposite way to the motion of rotation, *i.e.*, acts as a retarding force.

Let us now consider the actual magnitude of this resistance and the work lost in rolling friction. In the first place, it is clear that the extent of this loss does not depend only on the roughness of the surfaces in contact, for reverting to Figs. 9 and 10, the distance through which slipping takes place is greater in the former case although the sliding frictional resistance is less, and we cannot tell without an experiment in which of the two cases the total loss is the greater. Thus we cannot say without a trial whether a gain or a loss results from oiling or blackleading two surfaces which have to roll on each other. As Professor Reynolds has pointed out, between the two extreme cases of no frictional resistance and indefinite extension on the one hand, and infinite frictional resistance which allows no slipping to take place on the other (in either of which cases no work at all is expended in friction), there must be some point where the maximum of energy is lost. We have not yet arrived at any theoretical method of determining the amount of rolling friction for various substances, and must obtain results by direct experiment. We have before us a piece of apparatus which I have devised for roughly exhibiting to you how this can be done, and at the same time further illustrating the foregoing views.

Fig. 12 (p. 1197) represents a stand, A A, upon which surfaces of various kinds can be placed, and over these surfaces a truck moved by means of a weight (F) suspended over a pulley (K). The rollers of the truck can be changed for others of any required material, one of them having a pulley which by means of an endless band turns a pointer (D) thus recording on the large circular dial the extent to which the roller turns. The dial itself is fixed to the frame of the truck, and also another pointer which records on a horizontal scale the distance through which the truck moves. We have now upon the truck a weight of 14 lbs., and we will make four experiments, the first two with india-rubber rollers, first on wood and then on an india-rubber surface, and the last two with rollers of hard wood, on wood and india-rubber as before. In each experiment the truck is drawn through the same distance as shown by the horizontal scale, but from the readings on the circular dial it is evident that the rollers turn to a rather different extent in all four experiments. The following is a Table of the results :—

FIG. 12.



APPARATUS FOR INVFSTIGATING ROLLING FRICTION.

No of Experiment.	NATURE OF SURFACE.		Weight over Pulley (F)	Reading of Circular Dial.
	Roller.	Path.		
1	India-rubber	Wood	10 oz.	0·44
2	,,	India-rubber	9½ oz.	0·42
3	Wood	,,	6¾ oz.	0·3
4	,,	Wood	5¾ oz.	0·25

These results accord pretty fairly with the views set forth as to the nature of rolling friction, except that it might seem as if, in the matter of frictional resistance, the second and third experiments should change places. It should, however, be mentioned that the india-rubber of the roller and that of the path are of different degrees of hardness and pliability, obviously resulting in more frictional resistance than would be the case if they had the same properties.

From reasoning and experiments of this kind we arrive at clear ideas of the nature of the resistance to rolling, and although we cannot actually *see* the deformation which takes place at the point of contact of the surfaces of hard elastic bodies, yet we know that temporary deformation *does* take place, and we may conclude that this resistance is in all cases caused by the sliding of the surfaces in contact over each other. Hence we shall not be surprised to find that the laws of rolling friction set forth long ago by Coulomb, and determined by experiment, are identical with the simple laws of sliding friction, with the simple addition of the statement that the resistance at the centre varies inversely as the radius of the rolling body. The laws in a mathematical form are therefore simply :—

$$\text{Frictional resistance} = F = \mu \frac{R}{r}$$

Whereas before,

μ = co-efficient of friction, determined by experiment.

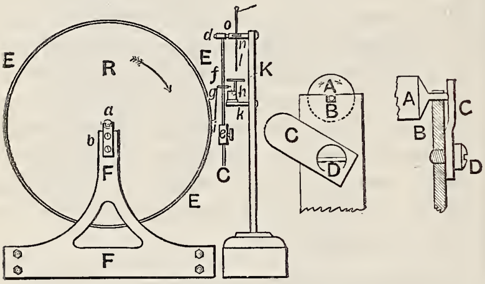
R = the load on the roller.

r = the radius of the rolling body.

The somewhat artificial idea, used by Coulomb and adopted since by other writers, of an imaginary arm which, multiplied by the load, gives the moment of friction, does not seem to be necessary, and certainly does not assist in making the action of rolling more easy to understand.

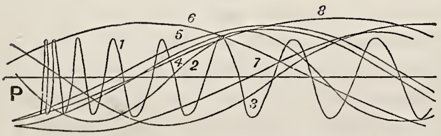
The general laws concerning the rolling and sliding of solid bodies which have now been given are for many purposes sufficiently correct ; it has long been known that the laws of Coulomb must only be regarded as convenient approximations to the truth. For dry surfaces (with which only we are concerned in this lecture) the first law, and, therefore, by implication the second, is practically accurate. When, however, the pressures are very great, and, as in the experiments upon railway brakes, abrasion takes place, Captain Douglas Galton found that the co-efficient of friction diminished for some little time after the pressure has been applied. Various suggestions as to the cause of this were made when Captain Galton's paper on "Brakes" was being discussed, such as the formation of little rollers by the abraded metal, the intervention of a film of air, the action of the heat generated, &c., but whatever be the explanation the circumstances are evidently abnormal, and for all normal conditions the first and second laws may be supposed to be correct. The third law has been examined both for very high and very low velocities, and for the latter, when the surfaces were tolerably hard, has been found to be absolutely correct. The apparatus by which Messrs. Jenkin and Ewing arrived at this result, and by which they obtained other results which we shall have occasion to allude to, consisted of a cast-iron disc, R (Fig. 13), supported on a frame, F F, by means of a spindle, *a*, turned down to a very small diameter to work in a bearing, *b*. Figs. 14 and 15 shows two enlarged views of the bearing and spindle, the former being square in section, and also a plate, *c*, acting to prevent any end play of the spindle. A strip of paper, E E, is fastened round the edge of the disc, which is then set in motion, and continues to revolve until the friction of the spindle in the bearing brings it to rest. During the time that it is gradually coming to rest, the pendulum (C) moves to and fro at right angles to its plane of rotation, and causes a continuous curve to be drawn on the paper band by means of a syphon recorder (K). Fig. 16 is a portion of the record thus obtained, and it can be seen how the wave length of the curves—at first considerable—gradually diminishes, and at last, at the point, P, the disc comes to rest. By analysing the curves, the law connecting the resistance of friction with velocity at speeds as low as ·0002 feet per second were obtained, with the result already stated.

FIG. 13. FIG. 14. FIG. 15.



APPARATUS OF JENKIN AND EWING FOR INVESTIGATING FRICTION AT LOW VELOCITIES.

FIG. 16.



CURVES TRACED ON EDGE OF ROTATING DISC.

The exact laws connecting the velocity and friction at high speeds is not known, but it is certain that the friction invariably diminishes at high speeds.

The simple laws of friction are thus sufficiently accurate for dry surfaces to enable them to be relied on in the solution of various mechanical problems. An important example in which this is done is in the determination of the power which can be transmitted by the frictional contact of a rope or belt over a pulley. In this case it is evident that the force transmitted is the difference in the tension of the belt on the two sides of the pulley. Now, reasoning upon the simple laws of friction, it may be proved that ratio of less tension to the greater

$$= \frac{S}{T} = \frac{1}{10^{.00758\,\mu\,\theta}}$$

where μ = co-efficient of friction (which for leather on cast-iron = ·42)
θ = angle embraced by the belt.

From this it follows that difference of tension on the two sides, which is equal to the force transmitted

$$= F = T\ (1 - 10^{.00758\,\mu\,\theta})$$

The action of the belt in passing over the pulley is precisely the same as that explained to take place in the rolling of bodies on each other, the belt, in point of fact, rolling on the pulley. The phenomenon of the slipping which takes place in consequence of the temporary extension of the belt is known as the "creep" of the belt, and involves a loss of from 1 to 2 per cent. of the whole power transmitted. By a similar mode of reasoning, the frictional resistance of coil of rope, the traction of wheels on elastic surfaces, and other problems, may be dealt with.

So far, the surfaces of the solids we have been considering have been of appreciable magnitude, and we have dealt with the friction taking place between one pair of surfaces only. We must now proceed to consider the frictional resistance which results from the contact of many surfaces where the area of contact of each is very small, and where we cannot examine the frictional resistance of each, but only the aggregate effect.

(1.) Such a case is the frictional resistance afforded by substances composed of a number of parts not cohered together, such as earth, sand, and grain.

(2.) Another case is the friction between the parts of a fibrous materials, such as rope, which we know is caused by the action of the separate parts upon each other.

(3.) Finally, we have the action which takes place in solid bodies when any change of form, however slight, takes place, and which we have strong grounds for believing is of the nature of friction between their ultimate particles.

If we observe a mass of dry earth, sand, or any granular substance, we shall see that the sides, if not artificially supported, have a certain inclination to the horizon, and that though this inclination is uniform for any one material, yet it differs for different materials. We can, by means of an arrangement in the lantern, examine this upon the screen, and you will see that whatever form I initially give any substance of this kind, its sides invariably assume a particular inclination.

This inclination is called the "angle of slope," or "angle of friction" of the substance, and is of great importance, being, in fact, the sole basis of existing theories by which such important problems as the pressure of earth and sand on retaining walls, tunnels, arches, &c., are dealt with. It is beyond our province to enter into the details of the reasoning by which the mathematical results are obtained, but it is an undeniable fact that the engineer, though employing them as a guide in general principles, does not rely upon the exact numerical results obtained by calculation, but allows a very large margin for the uncertainties of the case. For instance, the pressure on a vertical retaining wall is, by theory, merely due to the weight of material between the back of the wall and the plane bisecting the angle of complement of the angle of slope. This is simple enough to understand, and upon it the numerous tables of pressures are calculated; yet the greatest authorities have recently stated in a public discussion that the retaining walls they built gave them more anxiety than any other kind of structure, and their conviction of the general supremacy of practical over theoretical considerations in such cases. The explanation of this seems to be that it is not merely the frictional resistance that acts in the case of earthwork, but the cohesive action due to the varying hygrometric state of the mass, and that it is only the judgment obtained by long practical experience which can be relied upon to form a correct estimate of the conditions of the case. Still the failures in retaining walls do not appear to have been caused so much by a miscalculation of the pressure of the earthwork as by the failure of the foundations of the walls. A very high authority* recently stated that 99 out of 100 cases of failure are due to the latter cause.

As far as the action of the parts of a perfectly dry granular substance on each other, recent investigators have established the fact that the "historical" element must be carefully taken into account, that is to say, the effect of individual particles upon each other must be considered, and not merely their aggregate effect, even though we may not be able to examine the individual surfaces separately. Thus, in the behaviour of a mass of sand or grain, not merely the frictional resistance of the surfaces of the grains but on their shape must be considered. Professor G. H. Darwin, of Cambridge, and Mr. Isaac Roberts, of Liverpool, have independently and by means of different experimental apparatus, the former working with sand and the latter with corn, peas, oats, and other grain, arrived at very similar general conclusions and results. Both these gentlemen found that the grains apparently built themselves into the form of concentric arches, with their concavity towards the side on which the pressure was relieved, so that the pressure was considerably diminished from this cause. Moreover, that the initial position was unstable, and was caused by the irregular distribution of the grains, a certain amount of shaking or vibration causing the grains to fill up the interstices by a process of "settling." This amount of settling (which, curiously, in all cases appears from an examination of the figures to have been about 10 per cent.), resulted in a re-arrangement which caused a greater internal co-efficent of friction, and, therefore, reduced the pressure on the sides.

The object which Mr. Isaac Roberts had in view was to directly determine the pressure of grain stored in elongated cells or "bins." In America this method of storing is largely adopted, bins being used from 10 ft. to 12 ft. square, and from 50 ft. to 80 ft. high. In this country their adoption is quite recent, and it was because of the absence of the data needed in their construction in Liverpool that the experiments were carried out.

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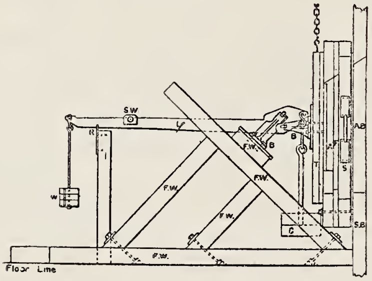
* Mr. Benjamin Baker, in his paper on "The Actua Lateral Pressure of Earthwork" (Min. Proc. Inst.C.E., vol. lxv., p. 140), to which paper and the discussion thereon readers are referred for much practical information on the subject.

The first set of experiments was made with comparatively small wooden bins, the largest of which was 96 inches high with hexagonal cross section, the inscribed circle of which was $20\frac{3}{4}$ inches in diameter. As the grain was gradually poured into the bin, the pressure on the movable bottom was registered by means of a suitable device, and the astonishing result transpired that in all cases this pressure entirely ceased to increase at some point before the depth of two diameters was reached. From a comparison of the pressures and corresponding heights, Mr. Roberts concluded that this was due to the fact that the grains formed "a self-supporting parabolic dome held in position by friction." Further experiments were made with bins of larger size, the lateral as well as the bottom pressures being obtained by means of the weighing apparatus (Figs. 17 and 18), both these machines being capable of weighing with great accuracy from one pound weight up to 1,800 lbs. Fig. 17 shows the machine for weighing lateral pressures, Fig. 18 that for bottom pressures, both being arranged to measure the effect on areas of 1 sq. ft., 4 sq. ft., and 9 sq. ft.

Fig. 17.



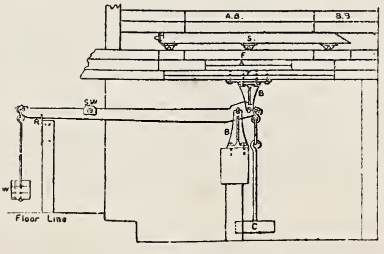


Fig. 18.

Apparatus for Testing the Pressure of Grain.

The final conclusions arrived at by means of a number of experiments, in which the depth of grain was gradually increased to a depth exceeding 50 feet, quite confirm those of the first set of experiments. The results for bottom pressures are expressed in the following manner:—

Let a = cross section of column of grain in sq. ft.
d = diameter of inscribed circle in ft.
w = weight of grain in lbs. per cub. ft.
c = constant, determined by experiment.
Then if p = pressure upon the bottom in lbs.

$$p = a \times d \times w \times c$$

Now for wheat c = ·84, for peas c = ·96, and if the value of unity be adopted, the margin will be on the safe side. Then the expression will finally stand—

$$p = a \times d \times w.$$

The lateral pressures cease to vary after a height three times the breadth of the aperture is reached, and may be considered constant per unit of area at any point of the bin above that height; the value of this pressure for all grain may be estimated at 50 lbs. per square foot. Mr. Roberts, however, recommends that in actual construction the calculations of the strength of any wall or partition should take four times this value, or 200 lbs. per square foot.

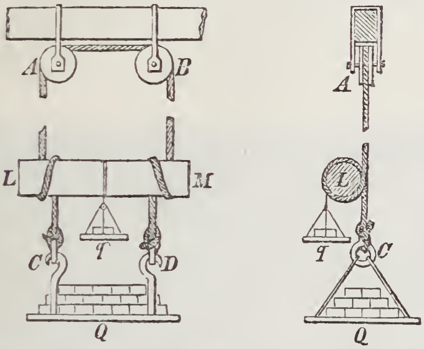
(2.) We have already considered the friction on the external surface of ropes and bands, and we must now study the friction which takes place between the separate parts of which such substances are made. This friction is of considerable importance in questions of transmitting power, since much work is lost in the use of ropes and stiff leather belts from the continuous bending and unbending which takes place in passing round a wheel or pulley; indeed, this fact has led to the invention and introduction for collieries of a special form of wire rope, the resistance to the bending of which is much less than with the ordinary form.

The rigidity or resistance to bending of ropes was investigated by Coulomb by means of the arrangement shown in Figs. 19 and 20 (p. 1201). A loaded platform, Q, was suspended from a beam by being attached to the two ends, C and D, of a rope. This rope passed over two pulleys, A B, fixed to the beam, thus equalising the pull in the two portions, which were each wound once round a cylinder, L M. The frictional resistance of the rope to bending was then measured by having a smaller loaded platform, q, suspended from the outer edge of the cylinder, as shown in Fig. 20. The results of these experiments showed that the resistance to bending depended (1) on the nature of the rope; (2) on the force transmitted; (3) on the extent to which the rope was bent; the rigidity (B) of the rope being represented by the expression—

$$B = \frac{a + b\,P}{r}$$

where a and b are two constants, depending on the nature of the rope, and P and r are respectively the force transmitted, and the effective radius of the pulley and rope. Thus with a rope 1 inch in diameter, raising a weight of half a ton over a pulley 1 foot in diameter, there would have to be an extra force applied of more than 50 lbs. in order to bend the rope.

Fig. 19. Fig. 20.



Apparatus of Coulomb for investigating the Resistance of Ropes to Bending.

When a rope passes over a single pulley transmitting some appreciable force, the resistance to bending causes the rope to be deflected outwards from the direct line of approach, so as to come into contact with the pulley rather later than it otherwise would. A similar effect is observed as the rope is leaving the pulley, but now it is bent inwards from the line of recession, and there is consequently a larger arc of contact on this side.

The amount of this deflection is much greater in the former than the latter case, and is, according to Eytelwein (quoted by Cotterill):—

$x = c\,d^2$
where d = the diameter of rope in inches
$c = 0{\cdot}47$ for hemp ropes.

This, however, is only correct for small pulleys and light loads. For leather belts the resistance, though appreciable, is of uncertain amount, and is usually neglected.

Although we have regarded the friction between the fibres of a rope in its prejudicial aspect, we shall see in the third lecture that it is this internal friction which enables rope and fibrous materials to be manufactured; but I will not at present say more on this subject.

(3.) We have now to consider the action which takes place between the internal parts of solid bodies. When a rope is bent, we can readily account for the sluggish manner in which it tends to partially return to its original shape, by conceiving that it is only gradually that the elasticity of the individual fibres can overcome the internal resistance acting between them. The frictional resistances to change of form are in this case easy to understand and trace. Not so, however, can we reason with regard to the case of homogeneous solids. We do not know the nature of the forces binding the ultimate parts together, and we cannot at first say whether the resistance to change of form may not be entirely due to some force of attraction, or whatever else the so-called resistance of cohesion may be, especially in the case of bodies which, when slightly distorted, return exactly to their original form.

Unless, however, we are to assume that the ultimate parts are themselves elastic bodies capable of change of form, we must admit that every change of form of the solid must be accompanied by relative motion of its parts over each other. The question then naturally arises, is there anything in the behaviour of solid bodies under the action of stress analogous to the behaviour of fibrous bodies? Many years ago Sir William Thomson measured the extension of copper wires for gradually increasing loads suspended from them, and then measured the amount of contraction which occurred as the loads were gradually removed. He found that although the copper wire returned to its original form when all the weights were removed, yet its length during contraction did not agree with that during extension for corresponding weights. Thus, since its elasticity was perfect, there must have been, over and above the mere tenacity of the wire, some resistance to change of form occurring, doubtless, both in extension as well as contraction, the nature of which corresponds to the friction between the fibres of the bent rope.

There are a large number of physical facts which point to the same conclusion; such, for instance, as the creaking of tin; but the most striking evidence is derived from the facts which support the mechanical theory of heat. Suppose the surfaces of two solids placed in contact and rubbed over each other until, by the removal of projecting portions on each, they become smooth, and that there is then no appreciable wearing away of either. When this stage is reached, work has still to be expended in maintaining their relative motion, and this work is now known to have its exact equivalent in the heat produced. We believe that the friction of the particles over each other sets up molecular motion, which is communicated by internal friction throughout the whole mass. No theory in physical science has led to more important results than this, and none rests on a more sure foundation, so that we need have no hesitation in considering that the resistance to change of form, as, for instance, in bending a metal bar, which results in the production of heat, is due to the same cause as the surface resistance.

We have now examined the chief facts in the friction of solid bodies, and we see that the resistance, whether external or internal, is simply due to the same cause, viz., the rubbing of the individual molecules over each other. Further than this we cannot at present go, for when we know definitely what the nature of this molecular motion is, we shall have solved the great problem of the constitution of matter itself.

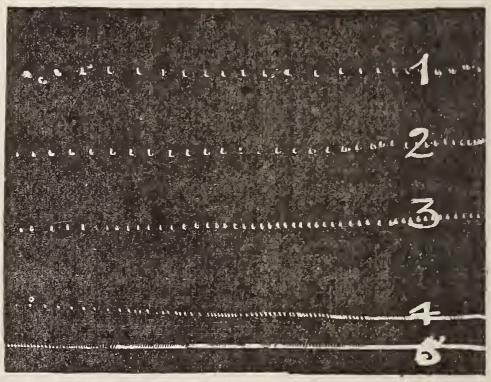
Thus I hope that the answer to the question which is put from time to time, viz., What is friction? has, in the case of solid bodies, been made clear so far as an answer can at present be given.

In conclusion, we may show that all the facts we have discussed are thus accounted for, at any rate, so far as the point to go further than which would involve a knowledge of the molecular constitution of matter, and at which point we must for the present be content to stop. These facts referred to all resolve themselves into the first law of friction (which includes the second) and the third, with the rider to the latter, that at very high velocities the friction somewhat diminishes.

Now, many writers have thought it necessary to propound a special theory of the physical constitution of the surface of bodies to account or the laws of friction. This theory is that the surfaces are serrated like the teeth of two saws which fit into each other, and that it is in raising the upper body up as each tooth is passed that the work of frictional resistance is expended, the deeper the serrations the greater being the frictional resistance.

A writer in a scientific journal, in an article* on "Friction," has gravely attributed the musical (?) note which bodies sometimes make in frictional contact to the direct action of these grooves, and has proposed to calculate the co-efficient of friction from the number of vibrations. I will produce with this stick of wood a note (which whether musical or not is a matter of taste), and I do the same thing five times across a piece of ground glass which I now place in the lantern, and you will see (Fig. 21) that I ought, from the marks produced, to have had five different musical notes, and five (or from the figure more probably fifty) different co-efficients of friction. I need scarcely say the musical note was the same, because I used the same stick of wood, upon the length of which alone depend the longitudinal vibrations set up within it which give the note emitted, the note having nothing whatever to do with the number or distance apart of the imaginary serrations.

Fig. 21.



Auditory Effects of Friction.

The theory of serrations has been so often propounded and supported by arguments and by calculations, that it must be briefly considered. There is no need to enter into the arguments in its favour, since there are two fatal objections against it. One is that for smooth bodies it is perfectly impossible by any optical means we possess to detect any such serrations, or even minute raised portions, on the surface—the body can thus only be raised through a distance exceedingly minute—therefore in order to obtain the equivalent of the work done, the body must be raised through this minute distance with a frequency such as to cause the velocity of motion to be very great. The kinetic energy generated at each rise of the body, however, varies as the square of the velocity imparted to the body, and by taking any special case and making a calculation it at once becomes evident that the theory cannot be maintained. The other objection is still more obvious. In propounding the theory, a sketch is usually given of a section of the serrated surfaces which are assumed to have parallel grooves. Now, this is altogether inadmissible, for what projections there are must be distributed more or less uniformly over the entire surfaces, and the idea of any falling into grooves cannot be seriously entertained.*

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* *Mechanical World*, December 11th, 1885, p. 421.

The simple explanation of the first law of friction seems to be this. Supposing the surfaces to be smooth and worn to their normal condition, there are even then only a certain very limited number of points in contact (*vide* the best surface plates), and further wear merely removes groups of particles, leaving other hollows, or if no wear is taking place, merely pushes down, or on one side, the projecting particles. Any increase of pressure brings a larger number of particles into contact, and so increases, to a proportional extent, the friction, or amount of rubbing and consequent heat produced. Hence the friction varies with the pressure. For low velocities, the constant resistance simply depends on the number of particles in contact, and, as this at any point is the same, the friction is not altered; when, however, the velocity is very high, it may be that the surfaces are slightly separated and the friction is thereby reduced; and it may also be that prominent particles, periodically displaced, but not permanently removed, may not regain their position so rapidly as to interfere with as many particles on the other surface as they otherwise would.

I trust you will now realise that it was necessary in order to make clear the connection between the various facts in the friction of solids, and to give a logical explanation of these facts, to discuss at length the time-honoured laws of friction. We have, however, treated of only one phase of the nature of friction, others being reserved for the next lecture.

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* Since this was written, a paper has been published in the "Minutes of Proc. Inst. C. Engineers," vol. lxxxv, p. 376, on "Recent Researches in Friction," read at a meeting of the Students (November, 1885), by Mr. John Goodman. The paper, after giving an interesting account of experiments on friction, proceeds to a theoretical consideration of "Dry Friction," which is said to be of a much more complex nature than that of lubricated surfaces (with reference to which statement *vide* Lecture II). The author supposes the nature of the surfaces of all solid bodies to resemble in structure the surface or "pile" of velvet, there being always some pile left, however smooth the surfaces may be worn. The physical properties of the material determine the "pitch of the pile," or number of piles per unit area. He then goes on to discuss, by means of diagrams, the effect of such a surface with the usual tacit assumption of grooves parallel to each other, and perpendicular to the plane of the paper. The work done in frictional resistance is supposed to be simply that required to raise the body each time it falls the depth of the pile, the fall generating the heat of friction. A formula is given for the amount of this work, which is of the form—

Work = number of piles × depth of pile × weight of body.

Various facts, such as the increased resistance upon reversal of motion, the smaller co-efficient of friction obtained with dissimilar than with similar metals, and the existence of the angle of friction are explained with the aid of diagrams. Several of the points assumed are open to very obvious objections, to which it is hard to see an answer; but it will be sufficient to dispose of the theory of the equivalence of the work done in raising the body and that actually occuring in frictional resistance. Some time must be occupied in the rising and falling of the moving body. Let us consider that occupied in falling; and suppose this to occur under the action of gravity alone, that is, assume (as in Morin's experiments) only the weight of the body acts. Then the time in falling will have a definite amount, viz.:—

$$t = \sqrt{\frac{2h}{g}}$$

(where h = the depth of the pile).

Now, in the first place, an obvious difficulty in the way of accepting the theory arises from the fact that, unless the body fell instantaneously it must fall to a different height for every velocity, depending upon the point where, from its trajectory, the respective parts of the slanting sides of the projections or piles come into contact. Captain Douglas Galton, to account for the decrease of friction at high speeds did, in fact, suggest the idea that the contact occurring between different parts of projecting portions at high and low velocities arose from such a cause (*vide* "Proc. Inst. Mechanical Engineers," 1879, p. 194). But this reasoning would lead us to expect a difference in friction at *all* velocities, which we do not find to be the case.

Beyond this, however, and without considering the nature of the outline of the imaginary projections, it may be proved, by taking values far beyond those which could possibly obtain, and calculating an imaginary case, that whatever the form of the sides of the projections, the body could not possibly fall the whole depth of the pile, even at a velocity of, say, 1-100 of a foot a second, and that above this speed the resistance of friction must depend directly upon the velocity of motion, whereas at speeds many hundreds of times as great this quantity, no difference whatever has been detected.

ADDITIONAL LECTURES.

JAPANESE ART WORK.

By Ernest Hart.

Lecture I.—Delivered Tuesday, May 4, 1886.

I have undertaken a difficult task, and its difficulties, instead of diminishing as I set myself to prepare for its accomplishment, have seemed to me to increase.*

Hardly a quarter of a century has elapsed since Japan (sealed for three centuries and impenetrable to European travellers or collectors) came suddenly into the family of civilised nations, and disclosed to our wondering eyes the treasures it had for so many centuries jealously guarded. The sudden dissolution of the feudal system, and the complete abandonment of the laws by which it had isolated itself from the European family of nations, were followed by its eager adoption of European institutions and customs. It hospitably welcomed English travellers, professors, artisans, and *savants*. It has only too readily assimilated European habits and tastes; the breaking up of its old institutions, and its lamentable abandonment of its own exquisite costumes, fashions, and decorations, have led to the dispersion of the art treasures once prized beyond all estimation. Hence the exportation to European countries, for the benefit of European collections, of artistic works which had accumulated for centuries, and the possession of a few of which was once the joy and pride of prince, noble, and knight. The daimios, or feudal lords, and the samurai, their two-sworded retainers, are now, alas, no more, and have given up their ancient possessions. The treasures of the temples have been largely destroyed or dispersed, and many of them are now in our keeping. The embroideries, the bronzes, the treasured swords, with their exquisitely chased hilts, guards, and mounts; the lacquered inros (medicine case) which every daimio or samurai wore at his girdle; the rare chests, despatch boxes, and perfume boxes of lac; the hanging pictures by great masters—too precious for more than occasional exposure to the view of the select few; all these fell suddenly, through war, through poverty, through change of tradition and habit, into the hands of merchants and dealers often ignorant of their value, and testing them rather by standards of inherent costliness and richness of material than of artistic merit. Thousands of rare and exquisite objects have been destroyed; bronzes of great antiquity and of unrivalled workmanship have been cast into the melting pot by tons, and weapons consecrated by centuries of tradition, and decorated with the works of the great masters of past time, have disappeared, and can no longer be traced. Happily, though tardily, the cultivated members of the Japanese nation have awakened to the irreparable loss which they have suffered, and at the present moment we hear with pleasure that much of what remains in Japan of their art treasures is being carefully gathered into museums. There they are catalogued, and preserved with the loving and tender care which a nation ought to show to its monuments of historic art. In Europe, the objects which came first into our possession in great numbers were imperfectly valued because they were imperfectly understood. There were few means of identification of the artists, or of comparison of old and new; of originals and copies; of good work and bad. The language in which the historic data exist is of enormous complexity, and learnt only by few at the cost of years of toil, and it may truly be said that until Mr. Ninagawa and Mr. Wakai, the most accomplished of Japanese experts and archæologists, made known their careful researches, we had in Europe but few data with which to guide ourselves in comparing the work of successive centuries as it came into our hands. To Mr. Wakai, and his pupil, Mr. Hayashi, now resident in Paris, we are all under great obligations, and to the latter I am especially indebted.

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* The historic arts of Japan are so numerous in their kind, so varied in their development, and so complicated in their detail, that the attempt to give even an outline of them to an audience not previously impregnated with Asiatic lore, and not accustomed to place itself at the standpoint of Eastern art motives, might well occupy a course of many more than three lectures; and it would be easier to attempt such a prolonged course than to endeavour to condense even a superficial review of the subject within three lectures. I shall deal, therefore, only with a small part of the subject, and that treatment must necessarily be rapid. Happily for those who desire to pursue the subject in many of its aspects, we have already, in recent literature, a number of books of unusually high merit and interest, to which I can refer you. Among these are the sumptuous work of Audsley on the "Ornamental Arts of Japan;" the eloquent and beautifully illustrated book of M. Gonse on "L'Art Japonais;" the instructive, erudite, and highly artistic volume on "The Pictorial Arts of Japan," which our accomplished countryman—my colleague in the medical profession—Mr. Anderson, is now passing through the press; the earlier, but interesting and valuable books of Dresser, Reade, and of Jarves and Sir Rutherford Alcock—pioneer workers in this subject—the admirable studies by Mr. Cutler of Japanese design; and the faithful and charming reproductions of Japanese art motives by Mr. Dillon. These books have obtained a reputation due not less to the singular beauty of the products which they describe and illustrate than to their fascinating novelty, and the invincible attraction which the genius of the artists of "the country of the Rising Run" have for Europeans, to whom they have opened a new world of art.

In Paris, M. Gonse, M. Burty, M. Duret, and M. Bing have followed up Japanese art studies with much ardour and great artistic taste, and with the skill in discriminative criticism for which French lovers of art are remarkable. In this country Mr. Franks and Mr. Anderson have, more than any other persons, contributed to our growing recognition of the importance of studying and discriminating the various schools and successive changes in Japanese schools of art, and to them we owe it that the British Museum possesses, and is now displaying, treasures of the keramic and pictorial art of Japan which will be increasingly valued, and which other countries may envy us. The collection at South Kensington has many treasures, but also much rubbish, and is very far from being complete or representative. It is a great pity that so great an opportunity is being missed, for shortly these treasures of the great masters of Japanese art will be unattainable. Meanwhile their acquisition may still be made with due knowledge, at a cost ridiculously out of comparison with the inherent and artistic value of the objects, not to speak of their vast and growing interest to the history of art.

I stand here a recent student of the historical succession and development of the schools of Japanese art, and it is because I have found great difficulty, which I have been at no small pains to overcome, in classifying and discriminating the objects which it has been one of the chief pleasures of my life during the last few years to collect, that I thought that it might be interesting to you to put before you some of that information which I have, under the practical pressure of difficulties in collection, been at pains to acquire. I have, in examining the Japanese art collections of England, been disconcerted to find how few facilities many amateurs seem to have had, and how relatively little attention they seem to have given to the discrimination of the works of great artists from the purely mercantile productions, more or less skilfully imitated, as articles of modern commerce. It is an exceedingly common thing to see in this country mere worthless commercial reproduction of great works shown with pride alongside of the masterpieces of men of extraordinary skill, and what should be deathless fame. The Japanese, like all Asiatics, is a skilful imitator. He has yielded easily and rapidly to the mercantile instinct.

It is a sad characteristic of the English dealer to require the reproduction of any saleable article by scores or hundreds. It is the essence of the true work of art that it is a unique creation of the imagination and the executive invention of a master. This unfailing characteristic of true art work European mercantilism sets itself determinedly to abolish, and it has done so with only too much success in Japan. The markets are flooded; the shops are full, and collections abound with superficial servile copies and cheap lacquered imitations of the old masterpieces. It is against this tendency, debasing the artistic instincts of the Japanese, and ruinous to the worth of European collections, that I wish, by this outline sketch which I am about to present to you, to protest. It is our duty, as art lovers, to study the characteristics of the original work of the founders of Japanese art, to instruct ourselves so as to prevent the possibility of what is now an easy facility for being deceived by common vamped up and worthless imitations, having more than the surface brilliancy to the eye, but none of the actual qualities of substantial material slowly built up, of delicate finish, originality, and accomplished and refined *main d'œuvre*, which a study of Japanese historic originals will reveal to the observant eye. This study is needed because the work of the Japanese was great in little. Its art is rarely monumental or grandiose; its dimensions were for the most part small, its decoration unobtrusive, its colouring sober, its finish faithful and minute, and the objects on which it was lavished often show to the common eye, and at a small distance, as no other and no better than the common modern travesties. The Japanese artist in metal or iron frequently worked as it were with a magnifying glass; the objects on which he lavished his skill are almost microscopic in dimensions. He aimed at overcoming every difficulty, at expending on a button (Netsuké) or a small menouki—the ornament of a sword hilt not more than an inch in length—art such as a Benvenuto Cellini would have lavished on a goblet, a shield, or a statue. Thus work which is in its strength of outline and vigour of expression almost worthy of Michael Angelo, may be found upon a menouki or netsuké not bigger than a thumb nail.

With this brief introduction I will at once proceed to speak of that department of art in which the Japanese are supreme among nations, and which was characteristic of the origin of their arts, and of the character of the nation. The art of Japan, as with most primitive nations, was an art born under the influences, and which set itself to satisfy the tastes, of the warrior and the priest; the art of the metal worker was lavished upon the armour and the sword of the soldier, and the images of the temple.

METALS, ARMS, AND ARMOUR.

I do not seek here to set out the history, of the origin of arms in Japan; the age of stone existed there as among other primitive people.

The earliest fables of the history of Japan are concerned with weapons with which the gods were armed; and in the temples of Japan are preserved arms of very early date, having an authentic history.

In the mythology of Japan, Izanagi and Izanami touched chaos with the spear point when they separated from the ocean the primitive islands of which Japan is a conglomeration. And Susanowo, brother of the Sun goddess, employed a mythical sword with which to kill the eight-headed serpent, whom he took care, however, first to intoxicate.

Authentic arms of the 8th century are the most ancient of those known to exist in Japan. They belong to the Emperor Shomu; date A.D. 724 to 764. There exists in Nara, the ancient capital of Japan, a Buddhist temple called Todaiji, founded in 764 by order of the Emperor. In the court of this temple are three stores containing antique treasures, and which have been known for the last eleven centuries under the name of Mitsugura, of Nara. They include objects of the greatest archæological history and importance, and especially those which belong to the Emperor Shomu; and it is these objects and the ancient catalogues of them which serve chiefly to constitute the history of the ancient metal work of Japan. Other great temples of the provinces around the ancient capital are also fertile in precious examples of the historic arts of Japan. Some of these are said to be prior to the 8th century, but as their authenticity is doubtful, it is unnecessary here to refer to them. Moreover, as the Emperor Shomu was the great patron of high artistic productions of the earliest known periods of artistic work in Japan we need not for a moment attempt to carry back history to more doubtful anterior periods.

From the artistic point of view, the metal work upon arms and armour in Japan presents itself under three kinds—chasing, incrustation, and *repoussé* hammer work. These three kinds of work are found either in simple form or combined. Sometimes the work presents pure examples of the chasing, incrustation, or *repoussé*, and sometimes the two or three kinds of work are found on the same piece.

To facilitate the review, I will briefly divide Japanese metal work into three series, viz.:—(1) Helmets and cuirasses; (2) Swords and sword mounts, and (3) Hieratic and domestic bronzes; and I will endeavour to sketch out their history in a few lines.

I avoid, for the sake of brevity, devoting any special mention to other arms, such as spears, bows, arrows, &c., because they are less frequently the subject of special artistic ornamentation, and hardly sufficiently important to form the subject of a special study in this rapid outline.

ARMOUR.

Archæological Period.—In the earlier times leather and skins were employed in the construction of helmets and cuirasses. The iron plates which were introduced into the helmet to strengthen the front part of it, and to protect the skull, appear to constitute the first step towards the subsequent production of the famous iron helmets of old Japan.

It is said that the first production of the characteristic armour of Japan was due to Takéno-Uchi, the great minister of the family Masuda, who himself forged arms and armour, and developing this art taught it to his warlike followers, and thus led the way to the success of the expedition of the Empress Jingu into Corea in the year 200. History, however, tells that iron helmets were already in use under the Emperor Sirjin, a hundred years before the commencement of the Christian era, although, owing to the rarity of iron and iron work, the leather cuirass was worn for a long time with the iron helmet. The descendants of Takéno-Uchi carried on in succession the art of forging iron, and the most celebrated of their works are spoken of in the early histories of Japan. No specimen of this early armourer remains.

The civilisation introduced after the Corean expedition and after the introduction of the Buddhist influence, opened a new era in all branches of literature and art in Japan, and it was from that time that the introduction of rich and artistic armour and its entry into the domain of works of art must be dated.

One only object of a date anterior to the Emperor Shomu deserves special mention, and that is a helmet composed of two white plaques, and surmounted with a lion forged by Munetsugu, the sixth successor of Masuda. This helmet was given to Kamatari, the great minister by the Emperor Genjin, about 668. The helmet made by Munemaro was given by the Emperor Kuammu to the conqueror of the Ainos, Tamuramaro, in 786.

The first armour consisting of helmet and cuirass cited in history is that which was made by Minekui, the twenty-second successor of Masuda. The armour was given by the Emperor Shujaku to the warrior Hidesato, who, in 940, killed the pseudo - prince Masakado, then in insurrection. It was a supreme honour for a warrior of that time to receive a helmet as a gift from the Emperor. A good helmet by a celebrated maker was considered an object of the highest value. It is only in the 10th century that records of these works occur. Of the 11th century there are numerous authentic examples, and many such objects are preserved in the temples and among the great families. The helmet of Yoshitsune, the celebrated general, and brother of Yoritomo, preserved in the temple of Kumara in the Province of Yamato, is described as having a semi-spherical form and being composed of thin triangular plates of iron, these plates being divided into eight series; four of which are covered with silver, and represent a white cross alternately with black. It is surmounted by a lion in gilt bronze, crouching and about to take a leap. The lateral plates of the two sides of the figure are decorated with lion cubs playing among peonies in gilded bronze, and chased in high relief. There is great freedom and flexibility of form in this work, but the general character is bold and severe.

Artistic Period.—From the beginning of the 12th century helmets and cuirasses were regarded as works of high art, and their perfection is due to Miochin Munesuke. A collection of these helmets has great artistic interest. The iron helmets are tempered to extreme hardness and tenuity, and worked with a hammer, and they assume most various forms. They are in high relief, and the iron, although thin and light, possesses a solidity which resists a heavy blow from a sabre. Sometimes the speciality of the artist is seen in the lines of the form which indicate his style; in others the designs and fancies worked out in the *repoussé* patterns constitute the speciality of the helmet. In these helmets of the Miochin period, it is impossible not to ask one's self how the artists have been able to achieve such high relief and artistic lines in material so intractable. The artist has obviously, in many of them, aimed at giving a character of elegance and delicacy, and at procuring great boldness and freedom of design in a material which could with difficulty lend itself to other than the simplest and least striking effects. The cuirass follows the same artistic lines as the helmet. Many kinds of decoration are introduced in cuirasses; the most simple of them, representing heraldic arms, animals, or birds, and sometimes other subjects, such as the Buddhist deities and the fabled warriors of early Japan. The other parts of the suit of armour are the mask, in iron, which covers the lower part of the face, and the arm-piece which is nothing else than a long glove. The iron masks which were worn by the warriors are perfect specimens of hammered iron. The mask was adjusted to the face, fitting it like a glove, and protecting the visage, while it served to give it, what was thought important by Japanese warriors, an expression of ferocity. The gauntlets and sleeve are decorated with smaller motives than the cuirass, and executed with great delicacy.

Among specimens of armour which I show you are:—

1. A helmet in form of a rabbit, in hammered iron *repoussé*. A work of Miochin (unsigned). a remarkable and very ancient work of the 13th or 14th century. *Repoussé* work in iron is not in itself difficult, but *repoussé* work in very high relief in thin, hard, hammered iron (so hard as this, which is intensely hard to resist sword cuts), and yet to retain the artistic effect, is a very difficult art. The helmet is worked in hammered iron of such thinness that, although very large, it weighs little over a pound.

2. A helmet in the form of a shell. A work of the utmost difficulty and highest artistic effect. A piece of the 13th or 14th century.

3. A warrior's (helmet) mask in hard ham-

mered iron. A very remarkable work, signed by Miochin Monokio, the second of the house, and a great artist. A *chef d'œuvre*, and of great rarity; 12th century.

4. A warrior's mask in hammered iron, with moveable face. Miochin Munéharu; 16th century.

5. A breast-plate in hammered iron, end of 15th century, with lion in relief, by Nobuiyé; a fine piece, very rare.

6. A complete suit of armour by a Miochin of the 12th century. The finest, I believe, ever brought to Europe except that in the Madrid collection.

A little portable incense burner, in hammered iron, chased, representing a fish (opening with a hinge) by a Miochin of the 16th century.

An articulated lobster forged in iron; and this exquisite dish shaped as the leaf of a lotus, and supported on the tendrils and seed vesels; a dream in hammered iron.

The temple of Kogukuji, at Nara, possesses the arm-pieces of the armour worn by Yoshitsuné. These celebrated pieces are most elaborately worked. The gauntlet is of chased iron, encrusted with a butterfly, with chrysanthemums surrounding the whole surface. The arm-piece has a branch of the same flower. These are encrusted with chased and gilded bronze, and have a rich and artistic effect which may well surprise those who have not been disposed to attribute Japanese works so elegant and so delicate to these early dates. The author of the work is unknown, but its date exactly corresponds to the moment when Miochin Munesuké appeared as an armourer.

NOTES ON THE MIOCHINS.

The authentic artistic history of Japanese armour begins with the history of the house of Miochin. The first personage of this great family of Miochin was Munesuké, who lived in the 12th century. Their true family name was Munesuké, springing from the ancestral house of Kino Munenori, who is identical with Takeno-Uchino-Sukune, whom we have already spoken of as being a forger of arms and armour in Japan. The genealogy of the family of Miochin show them to have descended directly from Sukuné. The family of Miochin were the official armourers of the Court, and it was Miochin Muneyoshi who perfected the work, departing from tradition by substituting the most various and agreeable art motives for the monotonous ornaments of the earlier times, and creating a new school, with its own artistic character. The honorary title of Governor of Azumo was given to this great artist as an official testimony of approval of his talent. The title Miochin was accorded to Munesuké by the Emperor Konoke (1142—1155), and became the family name. It is derived from *mio*, light, and *chin*, marble. Miochin Munesuké resided first at Kioto, and subsequently at Kamakura, where the new form of the executive government created by Yoritomo was seated. He created the family or house of Miochin, which counted in subsequent centuries many distinguished successors.

From the 12th to the 13th century ten generations of Miochin carried on the fame of the house, most of them leaving behind them renowned works which are still preserved in the temples, or among the great families. A celebrated helmet was that made for the Shogun Ashikaga Yoshimitsu, made by Muneyasu. The 17th successor of the house Nobuiye was a master as celebrated as his great ancestor Munesuke. The helmet which he made for Takéda is of great historical celebrity. A work of Nobuiye has always a character of remarkable strength and boldness. His lines and reliefs are large and severe, but are not wanting in grace. The hardest iron appears in his hands to be a soft and flexible material. He was a master of marvellous skill, and seemed to do with iron whatever he wished. Thus the sabre sword guards of Nobuiye are classed in the first rank, and the fashion of these sword guards commenced with him. I shall refer again to this in the chapter on sword guards. I show you here a breast-plate from a cuirass and some specimens of sword guards, due to the work of Nobuiye. There were other of the Miochins of great fame. Takayoski, who lived in the middle of the 15th century, and Yoskioniti, who lived in the 16th century, were the two great names among the Miochins which have lived in the annals of the house. These two and Nobuiye form what are called in Japan Nochi-no-sansaku; the three masters of posterity. Among the numerous pupils of Miochin, Nobuyasu, the most distinguished pupil of Nobuiye, is the only one who founded a new school, and this is known under the name of Saotomé.

In addition to forging arms and armour, some of the artist forgers, pupils of Miochin, frequently amused themselves with making smaller art objects in iron, especially in times of peace. These objects are generally of remarkable quality. The best known is the eagle of South Kensington. Mr. Alexander possesses also a quail by an artist of the same house of remarkable quality, and I show you here an articulated crab by a Miochin, and this small incense holder shaped like a fish, and the articulated cray-fish, all of them remarkable works in hammered iron. (See Catalogue).

SWORDS AND SWORD MOUNTS.

Of all the parts of Japanese arms, those which offer perhaps to amateurs the greatest attraction, are the Japanese sabre and sword mounts. These mounts are marvels of chasing, incrustation, and hammer work. The spears, bows, and arrows, or other warlike weapons, were all ornamented more or less, but generally their beauty was secondary to that of the sabre. To a Japanese of the warlike class the two swords which he carried in his belt were his continual companions. Their owners never appeared without them, their swords were their very life, and there has been no exaggeration in calling the sabre the soul of the samurai. Hence this weapon was decorated more than any other object, and it was upon the sword, its blade, its guards, its sheath, and its handle, that the highest efforts of the Japanese metal workers were concentrated. Of the blades, I show you some fine old specimens; their forging is a chapter by itself, which has already been much treated, and which I must at present leave aside. The idea of decorating the sword guards and mounts was sometimes pushed to the highest point of luxury and of artistic refinement, but, as a rule, it was chastened by the Japanese love of sobriety, of colour, and minuteness and delicacy of work from which we are now, unhappily, weaning them. Certain people from time to time decorated their swords and spears with profusion, but, as a rule, the sentiment of luxury was indulged by making the ornaments more and more exquisitely delicate without making them more gaudy. In some of the more modern guards, gold, silver, damascening and coral and mother-of-pearl, which were the jewels of the Japanese, are seen in profusion, so that the eye is dazzled by the brilliancy of the materials, and ceases to be capable of seeking out and admiring the artistic beauties of perfect design and workmanship. The earlier Japanese, belonging to the great periods of art—the 16th, 17th, and part of the 18th centuries—sought a special kind of distinction in discreet and low-toned ornamentation, hardly discernible, without care, by the modern European eye accustomed to showy brilliancy; but if the ironwork of the earlier guards be carefully studied, you will not fail to see that it rivals in mastery of detail, in technical beauty, and in originality of design, the finest of the metal work of the Middle Ages, while it greatly excels it in extreme minuteness of detail and perfect mastery of a kind of technical work in which time and patience were counted as nothing in the balance when pure perfection of result could be obtained by their expenditure. Thus a sword mounted with a plain guard in chased iron, besides the special merit of its blade, is of a value equal to the richest European weapon, by reason of the great perfection of the workmanship and design of its mounts. These sword guards, and these small ornaments applied to the handle, are not now sufficiently respected. Before the invasion of the new European manners in Japan, and the destruction of all their old weapons and customs, they were highly valued and sold at great prices. The imperial decree of 1871, which abolished the carrying of the Japanese sabre, put an end to the importance which was attached to them in Japan; and it is thanks to this change that we collectors have been able to purchase in numbers, and often at absurd prices, and to form into collections in Europe, works which were rare and remarkable in their day, and are now, in one sense, unique; for although cheap cast reproductions of the ancient iron guards flood the market, those who are careful will not fail to distinguish the exquisite chased work of the old metal-worker. All the old guards are of hammered metal. This has been confirmed by many examinations, and recently, Professor Chandler Roberts, F.R.S., was so very kind as to make seme examinations for me which perfectly attested the fact.

A collection of Japanese sword hilts and sword mounts is one of the most artistic and the most interesting which can be made. The subjects, the method of working, all speak of old Japan, its history, its art, its civilisation, its religion, and its domestic life; for in the subjects selected by the artists of Japan, nothing was neglected. Their favourite flowers, their favourite legends, their favourite gods, the emblems of their festivals, the illustrations of their proverbs, the heroes of their fights, their domestic life; all these are represented in delicate chasings, incrustations, relief work, and piercings in metal of a minute perfection such as no other nation has ever produced, and such as every other body of artists may well envy them.

Modern Japanese work retains much of the cunning of the old arts of which it is the descendant, but this work is produced under different conditions. Modern commerce having found a pattern which will pay, requires hundreds of repetitions of it, and we have now castings multiplying by the hundred one identical subject, all of which are worked up with skilful imitation of surface to resemble the fine engraving and damascening of early days. But this is all sham work; it is commercial work fabricated at the bidding of the manufacturer for an unheeding public which looks for glitter and show, and does not value the exquisite *main d'œuvre* of the original artist, whose every work was an object of conscientious interest to him, and whose every signed piece was one on which his reputation, his status at the Court of the Daimio, and his personal honour and reputation depended. Of these fine old works, there are now shown in the cases in the library of the Society many hundreds of specimens in the way of sword guards, menukés (applied sword ornaments), caps for the sword hilt, ends for sabre sheaths, and other parts of the sword mounts.

Another series of delicately-worked metal objects are the pierced metal beads through which passed the silken cord of the tobacco pouch or medicine box hanging at the waist. These beads, which in the olden time were exquisite works of art, are now imitated by the thousand or million in common struck metal thinly coated with a gilding, or cleverly imitating the patina of the various alloys, and such beads, sold at a fabulously low price, have so debased the taste of the ordinary observer that I have often observed with amusement that, looking at the beads of the 16th, 17th, and 18th centuries in my collection, superficial observers have said "Oh! yes, this is what you see in the Regent-street shops." The latter have the same relation to the ancient work that a struck German metal candlestick has to a work of Benvenuto Cellini; but even that difference is not one which is always obvious to the eye of the ignorant observer.

METALS EMPLOYED.

The metals employed in the production of sabre mounts are very numerous; besides the variety employed in Europe, the Japanese have a considerable number of alloys of patina or artificial surfaces which are essentially Japanese. There are two principal alloys which attract the attention of amateurs. The first is known as the shakudo; that is to say, an alloy of iron and copper, with from five to twenty per cent. of gold, which gives a black patina. This is, perhaps, the most beautiful of metals, its colour is charcoal-black, and its tone varies according to the proportion of the alloy; it gives capricious reflections of blue, violet, and reddish purple, and lends itself in combination with other metals to exquisite pictorial effects unknown to any other metal-workers than those of Japan. The second is known as the shibuichi, which is a greyish metal, an alloy composed of one-fourth silver and three-fourths copper; hence the name shibuichi, which signifies one-fourth. These denominations, however, are in each case theoretical, each tone of colour requires a different proportion of metal, and the tint of these alloys varies as much as do pearls, from slate grey to pearly grey.

PIECES WHICH FORM SABRE MOUNTS.

In order to avoid errors in translations, it is preferable to indicate the Japanese names of the different pieces which compose the mount of the Japanese sabre. Collectors only employ the Japanese terms, as we have no exact translation which can be employed without periphrasis. The following are the most customary denominations.

The handle is decorated at its extremity with a metal cap above, and a metal ring at its lower end, fitting above the hilt, these two pieces are called *fuchi-kashira*. Fuchi signifies a border, and kashira signifies head. On either side of the hilt handle, or hilt of the sword, are fixed two little pieces of metal which are known as *menuki*, which signify pin or pivot. The small piece which caps the lower end of the scabbard is known as *koriji*; the projecting piece of the scabbard, through which the suspending cord is past, is called *kurikata*. Not to enter into too many details of the minor pieces, I will mention only two detached pieces, which often fit into the sheath of the small sword, known as *wakizashi*. The first of these two pieces is known as the *kodzuka*, a small rectangular handle, which carries a little knife blade niched in the scabbard. The second is *kogai*, which originally served as a hairpin, or as some say, to suspend the scalp or head of warriors slain in battles. Each of these mounts was the object of the utmost efforts of artistic invention and executive skill. On them were lavished all the art of the designer, the goldsmith, and the damascener. The art is *à la loupe*, for they are extremely small, but the decoration, chasing, inlaying, and relief carving of these metal sword accessories forms perhaps the most remarkable chapter of Japanese art-workmanship. Fine collections of them afford examples of art metal-work which are unrivalled in the work of any other nation or of any time.

HISTORICAL NOTE.

The ancient swords and sabres of the Japanese appear to be devoid of any luxurious mounts. The prolongation of the metal of the blade worked cylindrically formed the hilt. The scabbard was of hide or bamboo, and frequently twisted round with threads of copper. Somewhat later the hilt was made of iron of the same thickness as the blade, and formed of two pieces of iron fastened together by pins (menouki), in rare cases ornamented with precious stones or with bronze rings. The religious impulse given by contests between the Shintoists and the Buddhists favoured artistic progress in the 6th century, and the civilisation imported by Buddhism perhaps added more to the growth of religion. Arms were brought to perfection at the same time that the palaces and temples were constructed, and at the end of the 7th century metal working had sensibly developed. The sabre of Prince Mumayado, or Shotoku Taishi, preserved in the temple of Shitennoji, at Osaka, affords proof of this. The history of Japan tells that the Empress Gemmiw (708 to 714) gave orders to the court of arms to bring to Nara the metal artist Karuta-no-Muraji of the province of Omi. The sword known as shitisei-ken (or the seven stars) preserved in the temple of Koruji in the province of Yamato, has a mount in gilded bronze. The art motives of the chasing of this sabre is the Indian grass known as "karakusa." The work is in pure style and simple taste, and delicate tracing. This mount is a specimen of the work of Haruta. The sword guard, known as yamagata, preserved at the temple of Todaiji of Nara, is also the work of the same school.

The metal chasers of this epoch did not make sword mounts their speciality. They made accessories for armour, menuke (applicas), and ornaments for the temples and palaces, and various objects of luxury. The art of the metal chaser, which flourished in great perfection in the 8th and 9th century, is illustrated by the mounting of the sword guard for sacrificial purposes by the celebrated priest Kukai, or Kobo Daishi, which is described as being a veritable jewel of art. The handle is entirely in gold, chased with Indian motives, and surmounted by two little statues of priests worked with great perfection.

From the 10th to the 12th century, art showed a great decadence. The wars of the two powerful families of Minamoto and Taira destroyed a great number of the treasures of ancient art. Not only did the prefects of the palace neglect the questions of art and industry, but the processes devised by the early artists died away and were forgotten.

The government of Kamakura, founded in 1186, gave a new impulse to the arts and industry, and everything again was regenerated

The mounting of swords occupied the first rank in Japanese art, and although the protracted wars were now ended, the effects of the political struggles and destructive warfare were long felt, and art only slowly revived.

The sword of Yoshitsuné is an example of the finest work of this period. The mount is entirely in gold, chased with pines and storks; 24 round appliques chased with storks are fixed on the scabbard in series of fours. The sword guard is adorned on each side with three similar birds. Many others not less admirable specimens of this period, are preserved in the Japanese temples.

The 13th century was again disturbed by wars and invasion. The Mongolian invasion of Japan in 1281 shook the whole empire, and taxed all its resources. The tradition is that a hundred thousand Mongolians descended upon the shores of Japan, after having conquered China, in three thousand vessels, but under the guidance of Hojo Tokimune they were beaten off.

The 14th century was not less troubled by civil war, which obscured the artistic sentiment. Art in Japan remained stationary, if indeed it did not undergo a further relapse; but the luxury which the daimios and generals imported into the decoration of their arms gave a new impulse to the progress of art chasing.

The mounting of the sabre which Prince Otono-miya gave, about the year 1332, to Takauji, the first of the family of Ashikada, is in chased shakudo, surrounded with a border of gold. The fuchi-kashira and guard are decorated with crests of the Kiri in relief, worked from the surface of the metal. The kogai and the menuki are decorated with three rudders floating in the waves.

The dagger of Kusunoki Masashige, who died in 1336, has been preserved by a collector of Osaka. It is decorated in chased shakudo in relief, with the chrysanthemum floating on a water-course, and raised on a background of nanako. These two specimens are described as admirable types of the progressive perfection of the art. The models, as to shape and size, of the 8th century were still preserved.

In the 15th century, the Ashikaga Shoguns encouraged a higher degree of luxury in the artistic decoration of the sword; and of this family, Higashiyama Yoshimasa was the most ardent protector of the arts. He surrounded himself with accomplished and ardent artist workers, among wthom the most celebrated chasers was Goto Yujo, whose remarkable talent has never ceased to excite the enthusiasm of Japanese amateurs. His work has never been surpassed. One of the finest known specimens is the dagger of Yoshimasa, belonging to a collection in Osaka.

The ornaments of the sheath are chased in relief on silver, and represent a dragon in the clouds. The hilt is of shark's skin, on which are applied a pair of menukis, representing Juro, the god of longevity, seated with his stag. Refinement in composition, grace in the execution, and distinction of style, are the aims which these refined artists kept in view, and which they attained to a degree which has never been surpassed.

The house of Goto maintained its authority during the succeeding centuries in the chasing of sword-mounts, the whole skill of the artist being lavished on the meneuk, the kodzuka, and the kogai, these three pieces together being known as the mitokoro-mono, which signifies an object for three places. The sword guards themselves were at this time confided rather to the hands of artists who worked in iron; the desirable quality of the guard being its solidity and its capability of resistance to a violent blow. Although these guards were, even at this early period, sometimes made in bronze, the finest were executed in hard tempered iron, and it is among chased iron guards that the finest metal work of these times is to be found. Guards in shakudo and shibuichi, or in bronze, had not become common until, the long wars of the 16th century being ended, the Government was fixed at Yedo, and gradually, during this time of long continued peace, the sword became an object of display. True warriors, however, always preferred sword guards in iron to those made in any other metal, and this preference has existed even down to the latest periods, and for swords which were only objects of luxury and fancy. No name of any artist specially celebrated in the chasing of sword guards is recorded before the 16th century. Sometimes they were made by the forger of the sword blade, sometimes by the armourer, and some armourers and makers of sword blades were most celebrated for their skill in chasing sword guards. Among the artists of the 16th century, three attained high renown, and the iron guards chased by their hands have for centuries been recognised as of the highest artistic value. These three artists are Kaneiyé, Nobuiye, and Umétada. An authentic piece from the hands of these artists was formerly sold as high as a hundred kobon of gold, a kobon of gold having the value of more than £1 sterling. In the collection which I have arranged in the Library will be found several specimens of all these artists. The work of Kaneiyé is peculiarly smooth, and he especially affected landscape effects in low relief, full of poetry and sentiment.

The works of Nobuïye are of a larger and more virile character, and instinctively express the force and grandeur of his conception. His iron is of the hardest temper, and the subjects are commonly chosen from objects of still life.

Umétada was more abundant in invention than the two former artists. Although characteristically energetic in design, his smooth iron has a war-like appearance. His taste is simple, and the subjects full of life. His cursive designs, treated with a chasing tool, are as supple as the sketches of a great master with the brush. Umétada is the greatest master of the iron chasers.

Alongside of the Gotos there arose in the 12th century a variety of schools of high celebrity and various styles.

Nara Toshiteru, appointed specially to the Shogun, had created a characteristic school of chasing of large and original design, so characteristic that it has left a continuous impression on the succeeding ages; and the Nara school, with its revolutionary and fanciful designs, may easily be recognised when once its first characteristics have been seized.

Hirata Donin invented translucent enamel, which he applied to chased metal, about the year 1700, and of which he and his successors long possessed the sole secret. His work is highly refined. Kinai, in the 17th century, furnished to the court of Yedo iron guards, pierced and chased, of the most remarkable beauty. My collection is rich in specimens of his work, and I would especially call your attention to the sword guards by Kinai chased with masks, and to others, chased with dragons. Tadamasa, who inhabited the quarter of Akasaka, in Yedo, created a style of sword-guard, chased in a large style of art, which has been named after him, so that guards of his school are known as Akasaka-tsuba. The greater number of the most distinguished artists came to reside at the military capital of Yedo, where all the Daimios were bound to have a residence during their temporary sojourn when they came to pay homage to the Shogun.

In the latter half of the 17th century the archaic traditions of the 16th century disappeared completely, the school of Goto alone remaining faithful to the style of Yujo, which had existed for 200 years. Under the fifth Shogun, Somin—known by the honorary title of Yokoya—Nara Toshinaga, Yasuchika, Nara Joi, were distinguished above their fellows, and produced the most remarkable works which Japan has seen in this style. The variety of subjects is considerable, and in the sword-guards are illustrated not only every variety of subject taken from still life but historical, mythological, and religious emblems and figures. To make these lectures practically useful to every collector, I have, with the unstinted and invaluable aid of Mr. Hayashi, prepared an alphabetical list of the great artists, to whom I have here referred, and of their principal rivals and followers, to whom I shall further have occasion to refer, with *facsimiles* of their signatures, as found in the pieces in my collection, and with some chronological data. I have given only the names of well-known artists, and the marks of celebrated setters. This has been hitherto, I think, a desideratum.*

SCULPTURE IN WOOD.

The earliest form of artistic sculpture in Japan, apart from temple and palace carving of the architectural order, of which I shall not speak, was hieratic, the carving of the Buddhist idols, of which the first specimens are attributed to a Korean who came to Japan in 577. The history of the glyptic art has recently been learnedly told and artistically illustrated by Mr. Anderson, in his great book on the "Pictorial and Glyptic Arts of Japan," now being issued from the press, and I can here only call your attention to a few characteristic specimens. I have been so fortunate as to secure carvings by Ritsuwo, a great master of Japan, of the 17th century, of the two temple guardians or Nio. These are exquisitely reproduced by the aid of heliogravure, by Mr. Audsley, in his "Ornamental Arts of Japan." They are miniature giants, minusculous colossi; and rarely perhaps has superhuman force and faculty been so powerfully conveyed in figures of this size. I show you also a singular statuette of the divine Indra trampling under his feet the spirit of evil; it is instinct with fire and force. It is not dated, but of great age, probably about 10th or 12th century, and a sculpture of the highest merit. Contrast it with the feeble artificiality of the modern Japanese statuettes reproducing the same subject, and it is like putting an original Michael Angelo alongside of a plaster cast. This Saitaka, leaning on his stick (Catalogue, p. 31) is of a later date, probably 16th century. It is singularly naturalistic and full of fine touches of the later domestic portraiture in wood statuettes. I show you here also an exquisite example by Ritsuwo, and bearing his full signature. This statuette of the minister Tenjin is vested with life and graceful dignity. It is evidently a true portrait and unexaggerated, and has the character of the mediæval Italian portrait busts.

This series of ancient masks carved in wood and signed by celebrated sculptors from the 13th to 17th century, were used in religious festivals in the "Nô dance" by the Daimios in their castles; they themselves and their families took part in the performance; and the masks and dresses worn reach the highest point of luxury in the 17th century. This life-size raven of the 16th century has a breathing vitality. The masks, No. 9 to 12, are masterpieces; one of the carvers, as his signature shows, had received the honorary title of Wakasa-no-Kami, Governor of the Province of Wakasa. The title of Hogen was frequently bestowed on artists of eminence; the semi-princely title of Honorary Governor of the Province much more rarely; but there are other instances The great treasure of my collection of wood-carvings, is, however, this superb statuette of Buddha, about 4 feet high, which I have received direct from a temple at Nara, in Japan, only this month. It is certainly not later than the 13th century, probably earlier. In serenity, dignity, and god-like character, in the calm majesty of pose, the grace and lightness of the draperies, it far surpasses any specimen of Oriental carving which I have seen; and in this my artist friends and critical Japanists concur. It has much of the old Greek character. Statues of this early date and singular perfection of carving remind us for how many centuries Japan has preserved a continuous tradition of art.

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* This list will be printed in the appendix to the catalogue of the collection, and will be obtainable by members on application to the Secretary.

The wood and ivory carvings best known in Europe, however, are netsukes. Netsukes are small objects used as buttons or toggles, for attaching to the sash or girdle the medicine-box (*inro*), or, at a later period, a pipecase or purse. The earliest known examples are said to date not further back than the 16th century, although others, of earlier date, are reported to be in existence. According to Mr. Anderson, the first professional carver of netsukes is said to have been a native of Kioto, named Rifuho or Hinaya, who worked during the greater part of the 17th century, and died in 1670 at the age of 69. The most celebrated worker was Yoshimura Shiuzan, who lived in the early part of the last century, and is the inventor of many designs which are repeated in close imitation even in the present. Those of his productions which are copied in the "Soken Kisho" (a book descriptive of art industries, published in 1781), will be recognised by all collectors, although the originals are no longer in existence. From his time the number of workmen multiplied, but with a few exceptions they were outside the recognised art circle, and the only records of their names will be found upon their works. It is only within the last twenty or thirty years that foreign demand and foreign liberality of payment have brought the carver of netsukes an adequate reward for his talent, but, unfortunately, the specimens do not gain in originality or power in proportion to their increase in size and elaborateness. The market is flooded with crude rubbish, vile forgeries, and elaborate and unmeaning groups of extreme complication but little artistic beauty.

In the appendix to the catalogue I shall give a fairly complete list of well-known artists in Netsuké, and a transcription of their signatures. No such text has hitherto been attainable, and I hope it will be found very useful. For the data I am indebted to Mr. Hayashi.

The netsuki carver, as Mr. Anderson has well pointed out, included in his range of subjects the whole world of visible phenomena, the personification of proverbial saws, the historic myths, and the favourite mythological legends of Japan. A collection of old netsuke, with their stories told and their meaning deciphered, is a history in ivory of the daily life, the historic incidents, and the legendary beliefs of Japan. Almost every netsuke has its own story to tell, either of religious iconography, of popular myth, or of domestic custom. Sometimes the netsuke is simply a reproduction of natural objects—flowers, plants, animals, or fish, but penetrated with a sense of natural beauty and enlivened with a gay humour which is eminently and almost unfailing characteristic of the Japanese, and of their naturalistic art. Each flower and tree, too, has its meaning. The pine tree is emblematic of old age; the chrysanthemum, the chosen emblem of the Mikado — the national crest; the *paullownia* or Awoi of the Shogun; the plum blossom is associated with the nightingale, it is the poet's favourite tree; the cherry blossom is their ideal of beauty, and with it is coupled the pheasant among birds, as is the willow tree with the martin. Sometimes the netsuki shows a deity clothed with all his attributes. The jovial pot-bellied Hotei, the god of happiness, with his lucky bag, his fans, and groups of children; or the thunder-god with his string of drums; or Daikoku, god of riches, with his rice bags, which fill with rice at every stroke of the hammer which he carries, and his attendant rat, the privileged Lazarus of his crumbs of rice. Sometimes the figure, as that of a well-known warrior, the Japanese Samson, Benkei, carrying off the convent bell of Miidera, which never ceased to wail "I want to go back," till he restored it; of a hero, Yoshitsuné, the Bayard of Japan, whose adventures are a never-failing art motive; of a fabulous animal, the dragon, emblem of empire, or the kylin, emblem of halcyon days of prosperity, a Buddhist animal, whose tread was harmless to the minutest insect; or symbolic birds—mandarin ducks which pine for their mates, and languish when their partner dies, the emblem of conjugal felicity; or one of the many emblems of filial piety, the boy before the cascade which turned to wine to cherish his aged parent, or pulling the miraculous bamboo shoots which rewarded his persevering winter search, or sacrificing himself to the tiger; all belonging to the mixed region of religious fable, poetic fancy, or popular superstition. Nothing has been more quickly and readily appreciated in Europe than the remarkable power which the carver in wood and ivory possesses of showing in objects so small a power of telling a story—either of humour, or of fancy, or of terror—such as in European art is rarely, if ever, lavished on subjects so minute, but more commonly reserved for larger and more showy and effective work.

Okimonos are larger carved works, a sort of exogenated and magnified netsuke, which have been, for the most part, made for the European market. They are brought over in great numbers. They are exclusively modern productions. They show remarkable dexterity, skill, and patience in the finest examples; but the majority of them are destitute of real artistic feeling, and are little more than showy and clumsy caricatures of the earlier works of Japanese artists, which were executed for patrons who had a definite sense of the meaning of the work, and who would not tolerate clumsy, inferior, or superficial qualities of design or execution.

Most of the older netsukes are executed in wood. The ivory netsukes, which are so abundant, are, for the most part, of more recent origin; and among collections of many hundred netsukes, in the hands of European collectors, there you will find that 90 per cent. at least, are inferior modern works which have little in common with the higher qualities for which such possessions will be permanently prized. As a rule, you should be on your guard against ivory netsukes. Until late years the Japanese had only fossil ivory and used it sparingly. Ivory netsukes are a drug in the market, because masses of inferior imitative work has been lately produced to meet the demand of the market. They need to be carefully scrutinised and compared with the fine old pieces which they inartistically reproduce. Out of several thousand signed and unsigned ivory netsukes which have been offered to me, and which I have separately examined, I have not, in the course of several years, found a hundred fine and original works.

To conclude, Japanese art has been highly—perhaps unnecessarily—praised; it has been unduly, and not always judiciously, depreciated. To appreciate the art of an Eastern race, trained in the religious systems of Buddhism and Shintoism, having its own myths, its own beliefs, its peculiar predilections and its special conventionalities, we must learn something of the alphabet of their art language, and something of the symbolism which it expresses. In the dragon we must recognise not merely a grinning monster, but a mythical ruler of the elements; in the kirin, the emblematic combination of strength with gentleness; in the wandering beggar, the ragged and distorted Tekkai—the ironically hideous anthropoid form—the merely human shell of an immortal soul, whose claims to respect are purely spiritual. We must read the stories which these fantastic groups tell, and enter into their fairy land of birds, beasts, and flowers. We must not, in an Oriental nation whose religious sentiment regards the human form as the unsightly envelope, temporarily clothing a soul always yearning after transmigration and escape, look for the Greek harmony of outline and worship of anthropoid beauty. But in many ways the language of art is universal; and when the Japanese artist works unfettered by the conventionalities and grotesque elements essentially due to the Chinese origin of his schools, he shows a grace of design, a love of flowers, birds, and landscape, a sense of colour, a power of representing vigorous intense action, a skill in composition, a decorative instinct which have never been excelled. His metal work is unrivalled for its original and admirable technique, its fertility and variety of resource in utilising simple metals, and in inventing new combinations of colour: true "pictures in metal" which have no rivals in European art. He was great in patience, in devotion, in self-sacrifice, in true artistic sentiment and character. These characteristics we can trace in direct lineage in the art products of the Japanese workers of the last 1,200 years down to the present day. If I have asked you to follow me through, I fear, a dry historic retrospect, it has not been because I wish you to be the slaves of names or signatures, but because I wish to rescue Japanese art from the somewhat ignorant and pell-mell system of collection into which it has been apt to fall owing to difficulties in the study, and to help to put it more and more in the hands of the art student and technical craftsman. It should not be a craze, for it is worthy to be a serious study, and it is in studying the merits and defects of the enduring works of the great masters of a past which is rapidly dissolving, that we shall most profitably learn the lessons of the art academies of the far East.

The Italian Ministry have directed that the great collection of musical works, which formed part of the Municipal Library in Rome, shall be transferred to the Accademia di Santa Cecilia. This collection has been described as the richest of its kind in the world.

Miscellaneous.

COLONIAL AND INDIAN EXHIBITION.

The Conferences have now been resumed in the Conference-room; on Wednesday, 6th inst., Mr. G. Vane read a paper on "The Pearl Fisheries of Ceylon;" on Friday, 8th inst., Mr. E. B. Biggar, on "Canada as a Flax-Growing and Linen Manufacturing Region;" on Wednesday afternoon, 13th inst., Mr. J. Capper, on "The Cocoa Nut Palm of Ceylon: its Products and its Uses;" and on Thursday evening, 14th inst., Mr. A. A. Burton, on "The Late Eruptions in New Zealand," with lime-light illustrations. This afternoon, Mr. S. Todd, C.M.G., will read a paper on "Social Condition of the Cape Colony;" on Monday, 18th inst., Capt. W. Clark, on "The Canadian North-West as a Field for Settlement;" Tuesday, 19th inst., Mr. F. W. Pennefather, on the "Social Condition of New Zealand;" Wednesday, 20th inst., Lieut.-Colonel Palmer, on "St. Helena: its Past, Present, and Future;" Thursday, 21st inst., Mr. W. J. Birt, on "The Forests and Farm Lands of New Brunswick;" and Friday, 22nd inst., Rev. Canon Cooper, on "Emigration to Canada." These meetings will be held at 4 p.m.

METROPOLITAN SEWAGE.

The annual report of the Metropolitan Board of Works for the year 1885, just issued as a Parliamentary Blue-book, deals amongst other matters with the question of the disposal of the whole sewage of the area. The two reports of the Royal Commissioners thereon were referred to a committee of the Board, under whose direction experiments were already being made as to the best means of treating the sewage at the outfalls with a view to its purification and general disposal. The following particulars are taken from the report:—

The first practical trials were made at the main drainage pumping-station in Grosvenor-road, a beginning having been made with 1,000 gallons of sewage, and the quantity treated having subsequently been increased to 100,000 and then to 250,000 gallons. The experiments with the larger quantities were carried on for about three months, and the result of them was to show that chemical precipitation of the matter held in suspension in the sewage could be satisfactorily effected by adding to it certain proportions of lime and protosulphate of iron, and then allowing it to subside for an hour or two in settling tanks. The locality of the experiments was then transferred to the outfall at Crossness, where apparatus was set up for the treatment of a million gallons daily. The treatment consisted, first, in the precipitation of the suspended matter by the method above mentioned, and then in the pressing of the deposit or sludge into masses of smaller bulk.

Before extending the operations to still larger quantities, it was thought desirable to obtain the opinions of some independent chemists of the highest standing upon the value and efficiency of the process which was being applied. Sir Frederick Abel, Dr. Alexander Williamson, Dr. Odling, and Dr. Dupré were accordingly requested to examine the process and give their opinion upon it. Having made numerous experiments under various conditions, they definitely advised the adoption of the process of precipitation by means of lime and sulphate of iron, which they found to produce a fairly clear effluent water.

They were of opinion, however, that in hot weather something more would be necessary to insure complete immunity from offensive effluvia arising from secondary fermentation. What was required seemed to be an oxidising agent which would not only effect the immediate destruction of any unpleasant odour still remaining after chemical precipitation, but which would at the same time prevent the further development of offensive gases. It was found that permanganic acid was effectual in accomplishing both these objects, and the four chemists above referred to have lately given it as their opinion, after careful observation, that, if the effluent produced as above mentioned by precipitation with lime and protosulphate of iron be subsequently treated with manganate of soda and sulphuric acid, it will be deodorized and purified to such an extent as to render its discharge into the river unobjectionable at all states of the tide.

The Board, has not yet finally decided to adopt the modes of precipitation and further purification above mentioned. The committee under whose direction the operations have been carried on, does not yet consider itself in a position to bring up a complete report and estimatesof cost upon which the Board may act.

As regards the disposal of the sludge, that is to say, the deposit from the precipitation of the sewage, the Royal Commissioners suggested that it could be applied to the raising of low-lying lands, or burnt, or dug into land, or carried away to sea. The application of it to land, either by depositing it on the surface or digging it in, is, it is to be feared, impracticable in the neighbourhood of the present outfalls at Barking and Crossness, by reason of the enormous quantity which would have to be got rid of daily. The daily deposit, after precipitation of the whole of the sewage, is estimated to amount to 3,000 tons; this, when pressed and the liquid drained off, will be reduced to 850 tons daily. The process of burning the pressed sludge has been tried in various ways, among others in a large Hofmann's furnace at Pluckley, and the conclusion arrived at is, that whilst this method of disposing of the material presents little difficulty, the expense of carrying it on without nuisance would be so great as to be prohibitory.

There remains the suggestion that the sludge should be carried away and cast into the sea, and this, according to present probabilities, is the course that will have to be adopted

EAST AFRICAN DRUGS.

Of curative drugs, the East African manifests but little knowledge. Near Lake Ugombo, a small wild aloe, when the green skin has been peeled off, forms an ice-cold and healing application to burns; and in the neighbourhood of Dar-es-Salaam, a highly aromatic plant, with hairy purple stalks, called *arcazamudi*, is reputed a good native cure for pains in the stomach. The Somalis occasionally eat the local variety of dragon's blood, a resin of acidulous flavour obtained from the *moli* tree (*Dracæna schizantha*). Between Zanzibar and Dar-es-Salaam occurs a creeper with bean-like, hairy, S-shaped pods having severe stinging powers; it is about four inches long, of yellowish brown colour, and is called *upupu*. The pain yields to cowdung and wood ashes. In the same region, a broad-bladed grass, called *mwanga mwitu*, enjoys some fame as a styptic.

Arrow-poisons come much more prominently within the range of native study, and most tribes use some description of vegetable poison for anointing their spears and arrows. The most important is a species of *Strophanthus*, either *S. hispidus* or *S. Kombé*, which will probably prove to be the sole source of this class of poison used on the eastern coast, from Zanzibar to Somali-land, and even far into the interior. The plant is a runner, bearing large, rough-ribbed leaves, arranged in clusters of three or four together. Each shoot consists of three branches, of which one bears the seed and the other two the leaves. The flower is yellow, with curiously tailed petals. The seed has the form of a huge military frog-button, with lobes nine inches long, and is the direct source of the poison. This, according to St. Vincent Erskine, is called *umtsuli* in Gaza or Southern Mozambique, and is so energetic that men wounded by arrows in the fleshy part of the leg have been known to die within three hours, and with small bucks the poison takes effect before they can run out of sight. He likens the active principle to strychnine. These facts quite accord with the description given by R. W. Felkin and A. W. Gerrard (*Pharmaceutical Journal*, April 9, 1881, p. 833) of the poison used by the Wanika and Wakamba tribes, west of Mombasa, except that several roots are supposed to contribute to the deadly effect. These authors mention an antidote composed of sundry roots reduced to charcoal, which, however, proved a failure on trial. Careful investigation of the *umtsuli* reveals the fact that it is a powerful cardiac poison, as powerful as digitalin, and more powerful than veratria, when injected under the skin. But it causes only nausea, vomiting, and some weakness when taken by the mouth. The flesh of animals killed by this poison is eaten by the blacks without ill effects. Probably identical with this is the "poison tree," from the roots of which the natives of Somaliland extract a black and pitchy substance for poisoning their arrows. Perhaps, also, the pitch-like poison obtained from the boiled-down bark of a tree used on the Rufiji river for application to arrows, lances, and even bullets; and the *muavi*, or poisonous decoction of the bark of a tree, employed in the trial by ordeal of the natives of the Nyassa and Zambesi valley, is the same article under another guise.

Indulgence in narcotics appears to be confined to tobacco, which is very commonly grown under cultivation. It is a special product of the Handei district, whence considerable quantities of the sun-dried leaf, beaten into little round flat cakes about two inches in diameter, are sent down to Pangani for export. The tobacco is coarse and strong, but of fairly good flavour. The Kiswahili use water-pipes (*kiko*), made of gourds of various shapes. They swallow the fumes in smoking, and seem to enjoy the paroxysm of coughing which results.

Correspondence.

SERICULTURE IN INDIA.

Mr. Wardle having very kindly sent me his report, I have read it with much interest. His zeal in the cause we must all admire and applaud, and I regret that my long illness has hitherto prevented me from seeing the results of his labours.

It appears, however, to me that he lays too much stress upon the value of wild silks, and he is wrong in saying that "the fibre of Indian Tussur silk is a better one than that of the Chinese, which is quite another species." I grant that it is another species, but the Chinese Tussur waste is worth, to-day, at least 25 per cent. more than Indian; I use considerable quantities of both. It is quite a folly to suppose that Tussur or any wild silk can be reared to pay, because in all cases it will cost as much, and in many (more particularly Tussur) vastly more than mulberry, and when done the cocoons are only worth about half as much. Wild silk has a future, but it must be limited beyond all question to what the jungle can produce at little cost, and that I consider is not a very large quantity; Mr. Wardle thinks otherwise. As he says, Tussur might be the fashion and might for some special purposes be as valuable as the *Bombyx mori*, but it would be a fictitious value, as its fibre, lustre, and dyeing properties are not comparable. Some twenty years ago I read in Dr. Ure's "Dictionary of Arts and Manufactures" that there was a species of wild silk (the Eria worm) grown in Assam, that was so abundant and cheap, that the natives over a large extent of country were clothed in it, and that it was so durable, that mothers hand down their garments to their daughters. At that time I was busy with my experiments on Indian chassum, which cost me so much money and labour before I succeeded. This description of Dr. Ure's so exactly suited and described what was wanted, that in March, 1865, I wrote to my agents in Calcutta, "with a monthly crop it should be produced almost as cheaply as cotton—that it can be produced for little or nothing is beyond dispute, or why are all the poor natives clothed in it?" From that day, (now more than twenty years ago) I have never been able to obtain any supply worth notice; each year I have imported a small quantity, but nothing of any importance. At the present time Manchester prints have to a great extent superseded it amongst the natives. Before going to India, in 1884, I had two acres planted with castor oil, in order that when I arrived there I might have some Eria worms reared under my own supervision, but I soon found that it was a mistake, as they required the same labour and attention as the *Bombyx mori*, and the cocoons were only worth half the money, as they could not be reeled, and must be used as waste; so I had my castor-oil plants dug up, and planted with mulberry, Wild silk can be used when produced at a price, but can never be a large article of commerce, like the *Bombyx mori*. In 1874, I bought 1,000 acres of land, at a cost of £3,000 or £4,000, in Upper Assam, for sericulture, but it was afterwards found that labour was too scarce and dear, and I then turned it into a tea garden; some years after that, in 1878, I made another attempt at sericulture at Madhopur, in the Punjaub, the Government being exceedingly anxious to promote cottage cultivation. At that time I had but little practical knowledge of the proper method of treating and rearing silkworms, and very foolishly, as it turned out, imported during two or three years a large amount—above five thousand pounds worth—of the best Italian and French seed, which was given out to the cottage native rearers, and for which I got absolutely nothing in return; it might have just as well been thrown into the sea. A very large sum was spent in various ways, most of it very foolishly, but all in vain—it was a complete failure; and well it might, when we consider the miserable huts in which the worms were reared, and the imperfect knowledge and want of cleanliness of the rearers. There must be ventilation, absolute cleanliness, and abundant space, if silkworms are to be reared with any chance of success. All these conditions are wanting in a native cottage. Although I joined the Government in offering prizes for the best cocoons, and everything possible was done, no expense being spared, it was all in vain, and I had to begin again this time, I hope, with a better chance of success. In August, 1882, the Government of the North-West Province gave me a grant of about 3,500 acres of jungle in the Eastern Dùn, on certain conditions, one being that I was to have 3,500 acres more when I had planted a thousand with mulberry, and as I have planted about two thousand acres I am entitled to a further grant. The Eastern Dùn was pronounced by the doctor of the district as so malarious during the rains as to render its cultivation exceedingly difficult and dangerous, and at first I had no end of trouble from that cause; it is, however, much better now, and as the jungle is cleared away and it is brought into cultivation, it will in time, I have no doubt, be as healthy as any other part of the Dùn. I have built a large number of rearing houses for silkworms, a shed for reeling the cocoons, also a large number of workmen's houses, or coolie lines as they are called, also bungalows for the managers, in fact everything has been done to insure success, and to show, if possible, how for the first time in the history of sericulture (at least so far as I know) it can be carried out and made to pay on a commercial scale; hitherto it may be said to have been altogether cottage cultivation. It is, no doubt, a large and costly experiment, but I have great hopes of succeeding. The mulberry plants grow most luxuriantly, but we have not yet had sufficient experience to say whether the climate will suit all descriptions of silkworms. Until this year, on a small scale, European seed has done very well, but this year the crop was destroyed by a thunder storm, and I am disposed to think that there must always be considerable risk attending sericulture, even under the most favourable circumstances. The Bengal multivoltine worm, which I have tried to rear during the rainy season, has not so far done well; it may be the climate, or it may arise from bad and diseased seed. If the multivoltine of Bengal should fail, some other species from China or Japan will have to be tried, as it is very important to have two crops in the rainy season, as without that the remuneration would be comparatively small. As time goes on, and my plantations grow, and are capable of giving a sufficient supply of leaf for rearing on a large scale, it will be possible then to have a thoroughly practical result that can be relied upon—Rome was not built in a day, neither will Indian sericulture. There are many problems yet to solve.

1. What part of India is best adapted for the purpose? as you must in all cases have abundant labour, cheap land, and above all, suitable climate.

2. What is the best system, cottage cultivation, or large rearing establishments under European supervision, similar to what is now being tried in the Eastern Dùn?

3. Will the climate and soil that suits one species of worm suit another? For instance, will the damp climate of Bengal agree with the Italian or Chinese worm?

4. What is the best kind, and what is the best system of planting mulberry? At the Dùn the trees are planted about fourteen feet apart, and the intermediate space is filled with plants, which are plucked and then removed when the standard trees are grown. These, and many other questions, time, experience, and careful observation can alone solve.

S. CUNLIFFE LISTER.

Manningham Mills,
Bradford, Yorkshire.

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Proceedings of the Society.

CANTOR LECTURES.

FRICTION.

By Professor H. S. Hele Shaw.

Lecture II.—Delivered January 25, 1886.

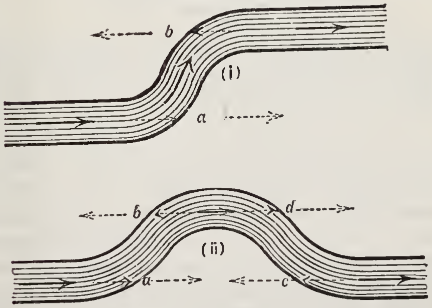
The Nature and Laws of the Friction of Fluids.

The motion of fluids has received as much attention from eminent mathematicians and physicists as perhaps any other subject except astronomy, and yet it is only two hundred years ago that the existence of what is in some respects their most important property was first pointed out. In 1686, Mariotte's "Traité du Mouvement des Eaux" was published, in which work the discrepancy between results calculated by theory and results obtained in practice was attributed for the first time to the fact that there was such a thing as fluid friction. The Italian engineer, Gulielmini, had a short time previously attempted to explain the retardation of flow in rivers, by assuming that the obstructions in their beds deflected upwards small bodies of water, which moving at first with a velocity less than that of the general mass of water, received an increase of velocity from that mass, and so caused a reduction in the mean rate of flow. Mariotte showed that in glass tubes the discrepancy between existing theories and practice also occurred, where he supposed such obstructions could not exist, and concluded that the retardation was really caused by friction against the sides of the channel in which the fluid flowed, and that this was communicated by friction to the contiguous particles, and so on throughout the whole mass.

Since that time innumerable experiments on the flow of fluids have been made, and many treatises written on the subject, and yet at the present day we cannot definitely say what exactly is the nature of that action which always dissipates the energy of fluid motion. Still, however, we know that in certain cases both the causes suggested respectively by Mariotte and Guglielmini come into operation together, while in every case there is some action like the resistance of friction corresponding to that which we were led in the previous lecture to conclude must subsist between the parts of the solid bodies. In addition to the above two causes there is a third, which, although more difficult to trace, we believe, from what we know of phenomena of diffusion, must come into operation, and in the case of gases to an important extent. The subject is, however, one of such difficulty that I propose to commence the study of it in a very simple manner, and discuss the flow of a perfectly incompressible fluid, that is to say, of a frictionless liquid, by means of the so-called "stream line" theory. We shall be compelled to admit that the motion of actual liquids is accompanied by some action corresponding to the friction of solid bodies. We shall then proceed to consider what is actually known from experiment about the motion of liquids, so as to be able to understand the laws of fluid friction, and finally deal with the case of gases.

In the first place, let us consider what takes place in the passage of a liquid through bent pipes or channels of uniform section. Let (i) Fig. 20 represent a smooth pipe in which the perfect fluid, moving in the direction of the arrows, is deflected round a double bend, and finally moves parallel to its original direction.

Fig. 22.



Flow in Channels of Uniform Cross Section.

The result of this is that at each bend there is an oblique reaction, the components resolved parallel to the original direction being equal and opposite for each. Therefore there is no resultant tendency to move the pipe bodily along, but only to turn it in a direction contrary to that of the hands of a watch. The dotted arrows in the other figure (ii) show that in passing round a second double bend the resolved parts of the reactions parallel to the original direction all balance each other, and as this is also obviously the case with the two equal and opposite couples, it is clear that the liquid has returned to its original line of flow without any changed velocity, and without having any resultant effect on the channel in which it has flowed. The same mode of reasoning leads us to the conclusion that the velocity of a stream of this kind is unaffected by the form of the channel, however tortuous, in which it moves, and, conversely, that the channel itself is unaffected by the passage of the stream through it.

Next, let us consider the effect of changes in the cross section of the channel. Let Fig. 23 represent diagrammatically particles or groups of particles moving at the rate, say, of 3 feet a second, then we may imagine 12 of these (shown in black) to pass a certain point each second. We may now suppose that these 12 groups of particles arrive at a portion of the channel where the sectional area is half that of the former case. The fluid being incompressible, they must pass this point in the same time as before, and they can only do this by increasing their velocity. If, for instance, they are 1 foot apart, and the former channel was 4 feet, they would formerly occupy a length of 3 feet. Now, the channel being 2 feet wide, they occupy a length of 6 feet, as shown in Fig. 24, and consequently, in order to pass a given point in one second as before, they must move at the rate of 6 feet a second, or double their former velocity. That is to say, the rate of motion of a liquid varies inversely as the area of cross section. Applying this to the case of a channel (Fig. 25) of varying cross section, we see that from the section (*a a*) to the section (*b b*) the velocity is increasing, and as this can only be obtained by an excess of pressure from behind, the pressure must be decreasing up to the latter point. From the section (*b b*) to the section (*c c*) the velocity is decreasing and the pressure is increasing, but the channel having returned to its original cross section, the pressure and velocity are again the same at this point. Thus it is clear that changes in the cross section of the channel have no effect whatever upon the final rate of flow when the cross section is the same as it originally was.

FIG. 23.

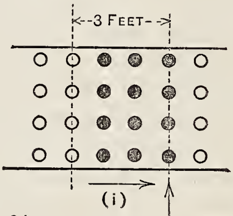


FIG. 24.

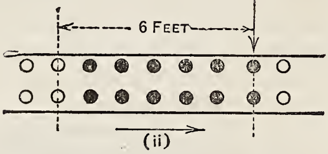
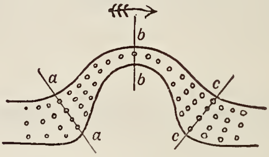


DIAGRAM SHOWING THAT THE VELOCITY OF FLOW VARIES INVERSELY AS THE CROSS SECTION OF THE CHANNEL.

FIG. 25.



FLOW IN A CHANNEL OF VARYING CROSS SECTION.

It is now easy to understand the stream line theory of the motion of fluids, and through fluids. Fig. 26 represents a channel, in which an incompressible fluid is moving in the direc-

FIG. 26.

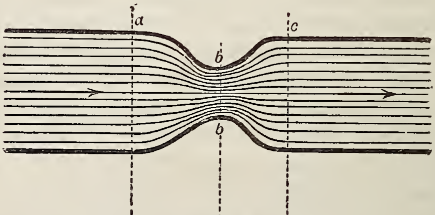
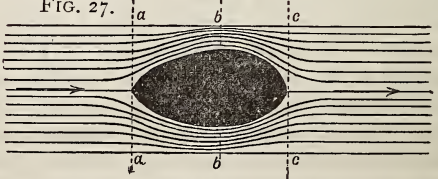


FIG. 27.



THE "STREAM LINE" THEORY.

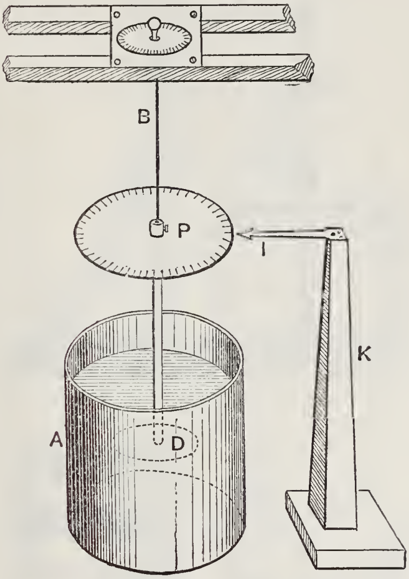
tion of the arrows. The lines in the section represent stream lines bounding imaginary streams of fluid; and it will be seen that, reasoning upon any particular stream between any two lines, the final condition of the fluid is the same as it originally was, and therefore there is no change of velocity in any of the separate streams, and consequently none in the whole body of liquid flowing in the channel. That is to say, the section at *a a* being the same as at *c c*, the conditions of flow in the two places are identical, and no loss of energy has taken place in passing the contracted section, *b b*. In exactly a similar way, we may show that, if the body shown in Fig. 27 (p. 1220) be moved through the fluid, the original state of the imaginary stream lines being again restored, there is no energy imparted to them by the moving body, and consequently there is no resistance whatever to the motion of the body itself.

We know well that in practice there always *is* a retardation of the flow of liquids, even in straight pipes and channels, and that when there are bends, even with continuous curves, the retardation is considerable. So, likewise, in the case of bodies moving through a liquid, we know that the resistance to motion is considerable, even when—as in the case of well-formed ships—the form is what is called "fair." Thus, now that we have made it clear that no resistance whatever to the motion of a perfectly frictionless fluid could in such cases occur, we may conclude that no such substance exists, and that there is an action of the nature of friction in fluids. We will now proceed to consider what is actually known of the exact nature and amount of the frictional resistance.

The earliest experiments on fluid friction were made about 100 years ago by Coulomb, whose apparatus consisted of a disc, D (Fig. 28), suspended by a brass wire, B, so as to be able to oscillate about a vertical axis in the vessel of liquid, A. The extent of the oscillations could be read upon a dial, P, by means of an index, I, supported on a stand, K. Thus by noting the time in which the disc came to rest in a liquid, and comparing with that in which for a similar initial displacement it came to rest in the air, it was possible to estimate the frictional resistance of the liquid to the motion of the disc.

Coulomb's experiments, although made at very low velocities, and leading him in one particular to an erroneous generalisation, proved conclusively that the laws of fluid friction were of an opposite nature to those of solid friction, and their method of statement is thus, as we shall see, entirely different. Since the time of Coulomb, data and results on the subject have been continually accumulating, such as those of Colonel Beaufoy, but without doubt the most important experiments that have been conducted are those by the late Mr. William Froude. Mr. Froude's apparatus consisted of a stout truck running on a pair of rails above a large covered tank 278 feet long 36 feet broad, and having for the most part a depth of 10 feet. From the truck could be suspended bodies of any desired material, having any required form, and the truck being drawn along the rails by a steam-engine at a rate which could be accurately regulated, the body was at the same time towed through the water beneath. The resistance of the water to the passage of the body through it, and also the rate of motion, were automatically recorded on a revolving cylinder.

Fig. 28.



Coulomb's Apparatus for Studying the Friction of Liquids.

The experiments of Colonel Beaufoy and Mr. Froude were made with solid surfaces of limited area in water of practically unlimited extent. Professor Unwin has recently published the result of experiments made by him with surfaces of virtually unlimited extent in a limited volume of water. He accomplished this by rotating a disc in a vessel of water and employed the apparatus shown in elevation and plan, Figs. 29 and 30. This apparatus consisted of a strong frame carrying a vertical spindle, S S, which could be turned at various speeds by a pulley, P, driven by a band from a hot-air engine. Upon this spindle discs of different sizes and various kinds of material could be fixed, so as to be within the cylindrical vessel of water, C C. The resistance to rotation was measured, not by the torsion on the spindle, but by the effect of the enclosed volume of water upon a cylindrical casing, A A (the effectual depth of which could be varied by means of a movable disc, E E), suspended by three wires to a frame, *b b b*. The scale pan, G, suspended over a pulley (*e*) to the edge of the casing served to measure this rational effect, while at the same time the velocity of rotation was observed by means of a speed indicator.

FIG. 29.

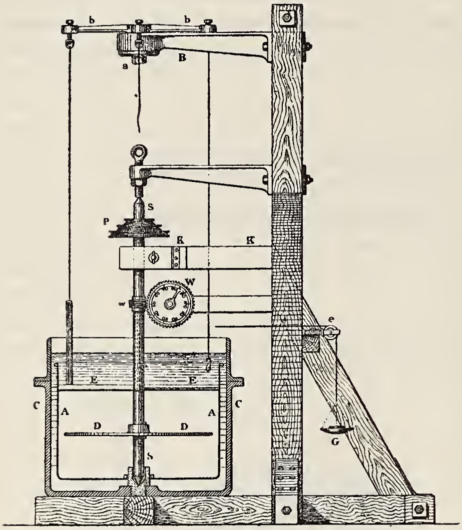
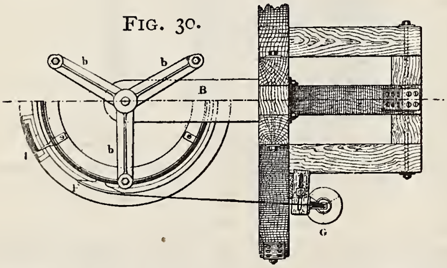


FIG. 30.



APPARATUS OF PROF. UNWIN IN EXPERIMENTS ON THE FRICTION OF DISCS ROTATED IN FLUID.

All these experiments which have been described were made with surfaces moving in a fluid, but concurrently a large mass of data upon the flow of water in a pipe or channel had been obtained, culminating in the elaborate and complete experiments which were carried out by M. Darcy, of the Paris Waterworks.

We can now discuss the nature of the results obtained by the various experiments, and it may at once be said that the friction between a solid and a liquid differs from that between two solid bodies in that it—

(1). Is *independent* of pressure.
(2). *Does* vary with the extent of the surfaces.
(3). *Does* increase with the velocity of motion.

These results are mathematically expressed thus:—

If F = the frictional resistance.
S = the extent of the surfaces in contact.
V = the velocity of relative motion.

$$\text{Then } F = f\,S\,V^n$$

where f and n are quantities both depending on the velocity of motion, and also on the nature of the surfaces. And what is required is to find under the various conditions of practice suitable values for f, or the "coefficient of friction" as it is called, and for n, or the power of the velocity to which the resistance is proportional.

Coulomb, as the result of his experiments on the motion of a body in a liquid, supposed that the amount of the resistance was independent of the nature of the surfaces and varied directly with the velocity, that is to say, that f was unaffected by the kind of surface employed, and n was equal to unity. Curiously enough, the earlier experiments upon the effect of surface in the case of the flow of water in pipes seemed to give the same result. The experiments of Beaufoy and Froude on the one hand, and of Darcy on the other, showed, however, that, except for very low velocities, these conclusions were quite erroneous. In the first place, it is now known that the roughness of surface has considerable effect in retarding fluid motion over it. This is well illustrated by the results which Professor Unwin has given, in Table on p. 1213, to show how closely his experiments with the rotating disc agree with the results obtained by Mr. Froude upon plank 50 ft. long.

Professor Unwin has plotted his results in the form of curves (Figs. 31, 32, and 33, p. 1223), in which each division horizontally represents one revolution per second, and each division vertically a resistance of one pound, acting at

RESISTANCE IN POUNDS PER SQUARE FOOT AT A VELOCITY OF TEN FEET PER SECOND.

Froude.		Unwin.	
Tinfoil surface	·232	Bright brass	·202 to ·229
Varnish	·226	Varnish	·220 to ·233
Fine sand	·337	Fine sand ...	·339
Medium sand	·456	Very coarse sand	·587 to ·715

a leverage of a foot on the suspended cylinder which enclosed the rotating disc. Fig. 29 shows the results with a cast-iron disc, the dark line being that with the space in which the disc rotated, adjusted so as to be only 1½ inches deep, the other curves representing those for 3 inches and 6 inches respectively. Fig. 30 shows the results with a bright brass disc, in which case the mean frictional resistance is obviously lower with the bright brass than it was with the rough cast-iron. Fig. 31 shows the result of four experiments with a rough and smooth disc, each in a rough and smooth chamber. The curves are exactly as would be expected, the highest being that for the two rough surfaces, the lowest for the two smooth ones, whilst the second highest is for the rough disc in the smooth chamber, and the third for the smooth disc in the rough chamber. With regard to the friction in channels, Darcy found that the resistance in clean, cast-iron water pipes was 1½ times as great as with a lining of pitch, while for old and encrusted mains it was twice as great as with new cast iron.

FIG. 31.

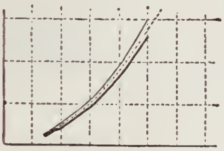


FIG. 32.

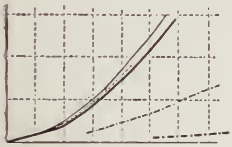
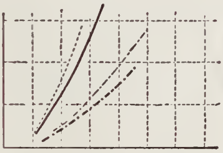


FIG. 33.



CURVES REPRESENTING THE RESULTS OF EXPERIMENTS UPON FRICTION OF DISCS IN FLUID.

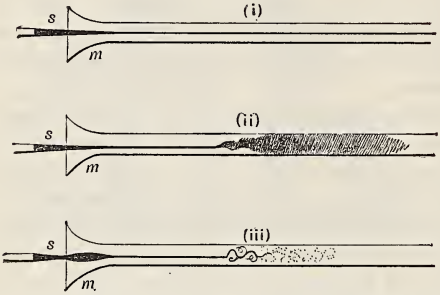
These general facts are not, however, sufficient of themselves to enable us to determine suitable values for the co-efficient for friction (f), which also depends in some way on the velocity. The fact is that, in spite of many attempts, it has been found extremely difficult to obtain such values so as to include both high and low velocities, and there is now reason to believe that this involves an important physical fact, which we shall presently allude to, and which would account for there being no single value of the co-efficient of friction applicable to all cases of the motion of fluids.

The search after some form for the various co-efficients of friction for the flow of water has absorbed a very large amount of time and labour on the part of the various authorities on hydraulics, for it must be remembered that we have only been considering the value for the retardation which takes place at a known velocity. There is also the case of the frictional resistance to increase of velocity; for instance, in the case of a river with a given surface slope. Here it is important to calculate what the velocity will be, and this might be at once done if the proper co-efficient of friction were known.

It has been remarked that Coulomb found for low velocities the value of the power of the velocity (n) was unity. This was for velocities of about 1 inch per second. At velocities of 6 inches per second, the power was afterwards found to be more nearly equal to 2, that is to say the resistance varied more nearly as the square of the velocity. Or more simply, while for low velocities the resistance doubled if the velocity doubled, and became three times as great when the velocity trebled. At higher velocities the resistance quadrupled as the velocity doubled, and became nine times as great when the velocity was trebled. Here, again, there was no exact value of the constant which was suitable to all cases, but the results of experiments of Mr. Froude and Professor Unwin agreed in a very remarkable manner, the value of n being in both cases, for smooth surfaces 1·85, and for rough surfaces from 1·9 to 2·1.

Now, what do the foregoing facts and laws of liquid friction reveal as to the nature of the resisting agency? It is certainly a remarkable fact that, after a certain velocity, the law of resistance should change in such a marked manner; and this particular point has been investigated by Professor Osborne Reynolds for the flow of liquids in pipes. There appears to have previously been no exact determination as to the exact velocity when the change in the value of (n) from 1 to 2 (or nearly 2) took place. Professor Reynolds experimented with colour bands in glass tubes (Fig. 34) about 4′ 6″ long, and fitted with trumpet mouth-piece (m) so that the water might enter without disturbance. The tubes were immersed in a tank, and the water was drawn through them, together with a streak of colour from a central tube (s). The results obtained were that, up to a certain velocity, the parallel and uniform motion of outer and inner water was maintained, as shown in Fig. 34 (i), and the coloured band extended uniformly through the whole tube. At a certain velocity, and at a certain point of the tube, however, the band always broke up, and assumed the appearance shown in Fig. 34 (ii). On viewing the tube with an electric spark, it was found that the band had broken up by the formation of eddies throughout the disturbed portion (Fig. 34, iii).

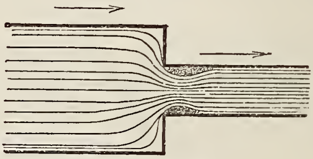
Fig. 34.



Experiments with Colour Bands in Tubes to determine Critical Velocity (Prof. Osborne Reynolds).

The general conclusions which seem to result from the various experiments made, are that there is a critical velocity at which water in motion breaks up into eddies, this critical velocity, though varying between comparatively wide limits, distinctly marking the change when the resistance became proportional to a higher power than unity. These results afford strong grounds for supposing that the dissipation of energy, when occurring to any appreciable extent, takes place by the setting in motion of masses of water in the forms of whirls or eddies. This is not only so in the case of abrupt changes of direction of flow, such, for instance, as shown in Fig. 35, or where a submerged body has not a fair form, but also on continuous and smooth surfaces, as we saw in the case of the glass tubes. Such eddies could, however, neither be formed or dissipated without some kind of action corresponding to that first conceived by Mariotte. And we now know that, as it has happened before in similar cases, Mariotte and Gulielmini were to a certain extent both right in their views, although both took into account only one kind of effect. Curiously enough, it was from experiments upon glass tubes—in which, as we have seen, eddies occur in such a marked manner, but which eddies Mariotte apparently never took proper means to detect, and which he supposed could not possibly occur in connection with so smooth a surface—that he was led to conclude that the resistance taking place must arise entirely from the friction of contiguous particles. Just as in the case of solids, we do not know what is the ultimate nature of internal fluid friction, but we have a definite theory as to the property of fluids by which these particles are brought into contact with each other, which we shall consider when we come to discuss the friction of gases. Arguing from this property, the resistance of two layers of liquid to motion over each other must vary directly with the velocity of their relative motion, and this would account for the results obtained by Coulomb at very low velocities. When masses of water are set in motion in the form of eddies, the resistance may be shown to increase from the cause as the velocity increases. Thus, from the combination of the two causes which act together, it is easy to understand why the frictional resistance at higher speeds increases at the higher power of the velocity.

Fig. 35.



Friction caused by Eddying Motion in a Liquid.

The results which I have quoted have been selected with the view of illustrating the properties of liquid friction, and we must for want of time pass over the important facts connected with the flow of rivers, the scouring action on their sides and bed, the data concerning variations in velocity of flow obtained by gauging operations, the formation and transmission of waves, the flow of water over notches and through orifices, the flow of semi-solid fluids, such as tar, and must pass on from the question of the "flow" of liquids through or around solid bodies to another aspect of liquid friction.

We have hitherto considered only the results obtained with solid bodies and fluids, and have referred to such effects as "fluid friction." We are evidently justified in doing this, because the surface of the solid is invariably wetted, that is, the liquid adheres to it, and consequently it must be the resistance in the liquid itself, and not that directly between the solid and liquid that retards the motion. This explains the fact observed by Coulomb that at very low velocities the nature of the surface of solids apparently does not affect the amount of the resistance to their motion in a liquid. A number of facts concerning the relative motion of fluids in contact with each other might be given, and also an account of various experiments, such as those upon drops, by Mr. Worthington, all of which entirely confirm the general conclusions at which we have arrived.

We have seen that the laws of solid and fluid friction are very different, but as long as we have the case of a solid moving in any considerable amount of liquid, or of a liquid through fixed surfaces, as when flowing in a channel we have only fluid friction. When, however, the quantity of liquid between the two moving surfaces of a solid is sufficiently reduced, it is obvious that the effect of the surfaces on each other must be felt, as, for instance, in the experiments of Professor Unwin, where the result of reducing the area of the chamber in which the disc rotated by lowering the plate E E (Fig. 29) was (contrary to what might be expected) to reduce the extent of friction, the larger area of surface in the former case causing more friction. There must be some point as the solid surfaces approach still nearer to each other where, since the laws of solid or fluid friction are of an entirely opposite nature, neither can hold. Such a case is that of lubricated surfaces. In the use of lubricants the amount of fluid between the surfaces may vary from the case of an oil bath to that of a bearing almost quite dry. Thus we might readily expect to find a considerable variation in the laws regulating the friction of lubricated surfaces, according to the nature of the lubrication, and we should certainly, in view of the two sets of laws which would respectively regulate these two extreme cases, not be prepared to exclusively employ either set of laws without very careful examination. Morin did experiment upon this point at considerable length, but his experiments did not by any means extend over a range sufficient to embrace the conditions of practice now common. He concluded that the laws of solid friction were applicable to lubricated surfaces, and "that with unguents, hog's lard and olive oil interposed in a continuous stratum between them, surfaces of wood on metal, wood on wood, and metal on metal (when in motion), have all of them very nearly the same co-efficient of friction, the value of that co-efficient being in all cases included between ·07 and ·08." The result of this has been the use ever since of the simple formula of solid friction with either Morin's value of the co-efficient of friction or some other. It has, however, long been suspected that this formula was not applicable. M. Hirn, for instance, thirty years ago,* said that—

> (1.) There exists a great difference between the phenomena which the friction presents of two pieces which slide over each other, and which are either dry and in immediate contact, or are separated by a bed of lubricating material (oil grease, water, or air).
>
> (2.) In the case of friction, which I call *immédiat* (in which the two surfaces are dry), the co-efficient of friction, otherwise the ratio of pressure and motive effort, is independent of speed, of surface, and of weight.
>
> (3.) It is not thus for friction which I have called *médiat* for those cases were the surfaces are separated by an unctuous material. Here the co-efficient of friction is always a function of the speed, of the charge (load), and of the extent of the surfaces in contact.

M. Hirn makes several other statements which are interesting, and bear on the subject, but which I need not quote. The whole question has been in recent years the result of elaborate investigation, but before proceeding to give a summary of the results we must make clear the puzzling differences in the employment of the term "co-efficient of friction." The term as employed by M. Hirn for the ratio of resistance of friction and load is used in the same sense as we have always used it for solid or *intermediate* friction. For fluids, however, the term we have used signifies quite a different thing from this ratio, and is in fact simply a convenient co-efficient in the expression for frictional resistance. Now, for lubricated surfaces the authority of Morin led to the use of a constant value for this ratio. It soon became evident from experimental results that the ratio was not constant, and instead of seeking a convenient co-efficient in a new expression, the idea has been in the case of some experimenters to find what values of the co-efficient would fit the old expression under different conditions, and in the case of others to find a new simple empirical expression, but still to have a variable co-efficient. M. Hirn employs the term as being a variable quantity in the former sense, and it is very easy to express the relation between his value of the co-efficient and the one we have employed for fluids.

---

* "Bulletin de la Société Industrielle de Mulhouse," 1855.

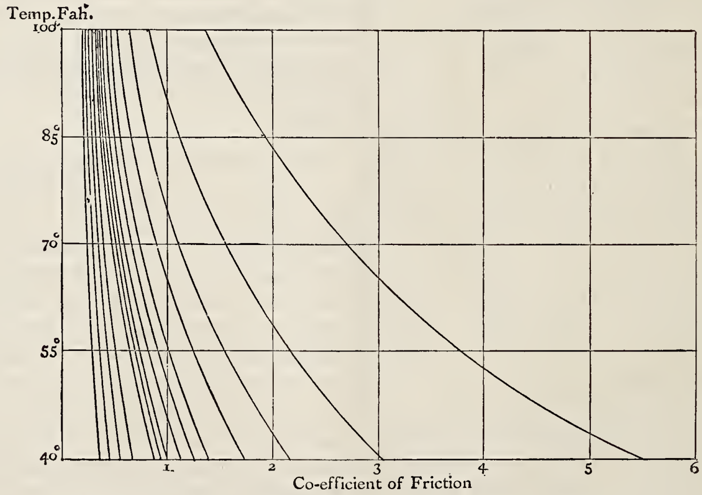
Thus if f = the ordinary co-efficient of fluid friction.
μ = the co-efficient as used by Hirn.
R = the pressure between the surfaces.

$$\text{Then } \mu = \frac{f S V^n}{R.}$$

Coming now to the actual experiments, we find M. Marcel Deprez* gives an account of experiments made with an electro-motor, in which he finds the co-efficient of friction (taken as $\mu = \frac{F}{R}$) varies from ·005 for a load of 145 kilos. to ·025 for a load of 550 kilos., giving a mean result of ·013. Here not only are the views of Hirn borne out, but the co-efficients were much lower than those given by Morin, and we were led by reasoning to expect such should be the case.

The most important experiments have been those made by Thurston and Woodbury, in America, and Beauchamp Tower in this country. We can only give a brief reference to the results obtained, which are quite what might have been expected; thus Mr. Tower says, "that his own results, speaking generally, were so uncertain and irregular, that they may be summed up in a few words. The friction depends on the quantity and uniformity of distribution of the oil, and may be anything between the oil bath results and seizing according to the perfection or imperfection of the lubrication. The lubrication may be very small, giving a co-efficient of $\frac{1}{100}$, but it appeared as though the lubrication could not be diminished and the friction increased much beyond this point without imminent risk of heating and seizing." With an oil-bath the co-efficient could be reduced to $\frac{1}{1000}$ (or ·001), and in one set of experiments the oil-bath worked with a co-efficient of friction which was $\frac{1}{7}$ of that in the case of a bearing very slightly lubricated.*

FIG. 36.



MR. WOODBURY'S RESULTS FOR FRICTION AT VARIOUS PRESSURES AND TEMPERATURES.

Mr. Tower's experiments were made with comparatively high pressures, and most of them at a uniform temperature; but Mr. Woodbury has obtained a number of results at varying temperatures, with pressures ranging from 1 to 40 lbs. on the square inch. With these light loads the resistance decreases as the temperature rises. Fig. 36 shows the curves obtained by plotting the results of a large number of experiments. Each curve is drawn for a constant pressure, that to the extreme left being the curve for 1 lb. per sq. in., the next for 2 lb. per sq. in., and so on up to 10 lbs. per sq. in.; the last four curves being respectively for pressures of 15 lbs., 20 lbs., 30 lbs., and 40 lbs. per sq. in. The points on every curve are found by setting off the co-efficients of friction horizontally, and the corresponding temperature vertically. The curves show a tolerably uniformity in the results, and indicate that the friction increases with the pressure, also that it decreases with the rise of temperature, but nevertheless they could not be represented by means of any simple formula.

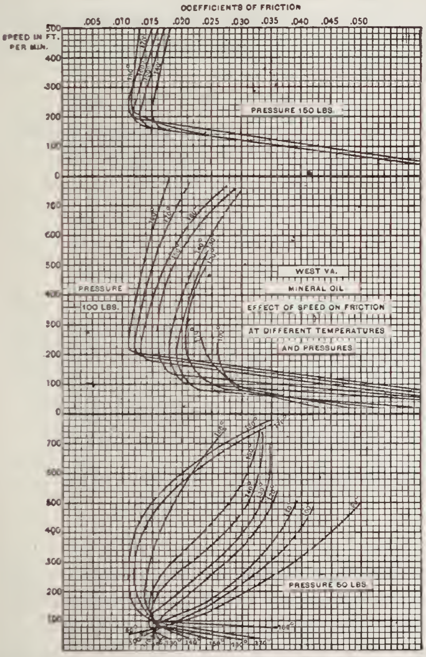
---

* "Comptes Rendus," Nov. 17th, 1884.

* Since these lectures were given I had occasion to carefully examine some of the results of Mr. Tower, and have called attention to a point which seems of practical interest. See *Engineering*, vol. xii., p. 458, *et seq.* 1885.

Professor Thurston's results, like those of Tower, show great variations, and make it evident that it is extremely hard to express the results in a mathematical form, even when they are obtained in special experiments under the most favourable conditions. Thus, take the results of three sets of experiments made at respectively 50 lbs., 100 lbs., and 150 lbs. pressure on the square inch. The curves so obtained are plotted as in Fig. 36, each one corresponding to one definite temperature (marked upon it), the co-efficients of friction being measured horizontally, and the velocities vertically. A simple inspection of these curves shows that, although the general result is that the friction at first decreased as the velocity increased, and then afterwards began to increase, yet any attempt to represent them mathematically would, if it could be done at all, lead to a formula altogether too complicated for practical use.

Fig. 37.



Experiments by Professor Thurston upon the Friction at different Velocities, Temperatures, and Pressures.

I have not previously referred to the connection between the temperature of the surfaces and the resistance of friction, and the reason is now clear, for the law of variation of friction with temperature cannot be stated definitely. Mr. Tower's results, however, indicate a great diminution of friction as the temperature rises. Thus with 430 revolutions a minute, the friction was only one-third of the amount at 120° F. that it was at 60° F. Also, though there is evidently some direct connection between the temperature and velocity of motion, it cannot be accurately expressed.*

In practice there are so many disturbing causes which it is impossible to control, that it would seem as if we must be content with general deductions, and use a method of computation, where it is necessary to do so, that will embrace the most unfavourable case. Thus there is some justification for continuing to use the century-old expression ($F = \mu R$). The margin allowed in text-books and elsewhere seems certainly estimated to be on the safe side. Thus, in the Science and Art Examination of 1872, there was a question on the work absorbed by a fly-wheel of 20 tons weight, with an 18″ shaft. The co-efficient of friction was given as ·1, and at a velocity of, say, 60 revolutions per minute, this would necessitate a special expenditure of 4 horse-power to merely turn that wheel in its bearings; whereas, by a properly designed and lubricated bearing, $\frac{1}{12}$ of a horse-power should be sufficient.

There are many other points concerning the friction of lubricated surfaces, but the general nature of the action taking place has been now made clear, and the practical questions arising from its study must be dealt with in the fourth lecture.

---

* Professor Thurston has suggested for the temperature of minimum friction at a pressure of 200 lbs. per square inch; the expression—

$$t = 15 \sqrt[3]{V}$$

where V = the velocity in feet per minute. On either side of this point in the thermometric scale, he assumes the friction to vary either directly or inversely with the temperature, according as the temperature rises or falls.

The friction of compressible fluids or gases must now be considered. The friction of gases is so much less than of liquids, that for most practical purposes its amount can be neglected. In recent years, however, when pneumatic tubes for transmitting messages have become extensively employed, and compressed air has become an important mode of transmitting power to a distance, and thus the actual loss from friction of gases has come to be an object of special vestigation. The experiments of M. Arson on the flow of air through cast-iron pipes led him to infer that the co-efficient of friction depended upon the velocity of flow in much the same way as the co-efficient in the case of the flow of water. Still more closely is this the case in the results obtained from experiments on the transmission of power by air in the St. Gothard tunnel. The engineer, Mr. Stockalper, proved that the formula for the flow of water in pipes deduced by Mr. Darcy from the experiments I have already mentioned, could be directly applied to calculate the flow of air, when the results are merely altered in the ratio of the density of air to that of water. Although Professor Unwin finds the value of the co-efficient smaller than that given by Stockalper when the calculation is made to allow for the expansion of air, yet the similarity in the laws of friction for liquids and gases is very marked, as, for instance, in the considerable diminution in the co-efficient of friction as the diameter of the pipe increases.

There is a remarkable and somewhat unexpected point of resemblance between liquids and gases in the fact that the friction is independent of fluid pressure. This result was arrived at from mathematical methods of reasoning by Professor Clerk Maxwell, in a paper read before the British Association in 1859. In the Bakerian lecture for 1866, on "The Internal Friction of Air and Other Gases," he published the results of elaborate experiments to test this theory. He found that the friction of air was the same for pressures between 30 inches and ·5 inch, and in fact that the calculated and observed results agreed very well with each other.

In 1876, Mr. William Crookes, in experimenting with the revolving vane of a radiometer to test the friction of the residual gas, found that this law was nearly correct up to a certain point of tenuity of a gas after which it entirely broke down. This led him to make a series of experiments upon the friction of a gas at high states of exhaustion, which gave results of the greatest interest in the study of the nature of gaseous friction. Maxwell's theory that the friction was independent of the density, assumed that the mean length of path of the molecules between their collisions was very small compared with the dimensions of the apparatus. Now, the mean length of path increases directly with the expansion, whilst the distance between the molecules only increases with the cube root of the expansion, and thus Mr. Crookes, who was able to work with pressures as low as ·02 millionth of an atmosphere, obtained results which Maxwell's theory did not include. The method adopted was to observe the rate of decrease of the arc of vibration of a plate of mica suspended by a fine glass fibre twenty-six inches long in an exhausted glass bulb. Without attempting to give the numerical results obtained, the diagrams Figs. 38, 39, 40, and 41, will enable an idea of their nature to be obtained. Fig. 37 shows the damping action on the vibrations of the frictional resistance at 760 millimetres pressure, or one atmosphere, and the quickly decreasing path of the mica plate in the successive swings is clearly seen. Fig. 39 is formed by joining the extremities of the length of successive arcs, and a logarithmic curve is thus obtained. Now at 1 millimetre, or $\frac{1}{760}$ of an atmosphere, the result was almost exactly the same, and the logarithmic curve almost identical with Fig. 39. When, however, the exhaustion had proceeded much beyond this point, the form of the curve began to change, and by the time $\frac{1}{50000000}$ of an atmosphere had been reached, the damping action was so enfeebled as to give the curve shown in Fig. 40, the corresponding logarithmic curve plotted as before from the

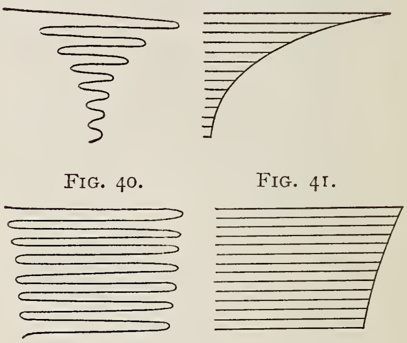


Fig. 38. Fig. 39.
Fig. 40. Fig. 41.

Diagrams showing effect of Internal Friction in Gases.

successive arcs was no longer of the same form, but nearly a straight line, as shown in Fig. 41 (p. 1228). These results not only throw important light on the nature of the internal friction of gases generally, but enable different characteristic properties of various gases to be examined. Thus the action of hydrogen was found to be entirely different to other gases; while, on the one hand, it has much less internal friction than other gases, it presents a very uniform resistance up to a high state of exhaustion, when it breaks down very suddenly.

Coming next to the friction of gases upon liquid surfaces, we have abundant evidence in nature of the reality and magnitude of this, not merely in the raising of ocean waves, but in cases such as the flow of rivers, where the retardation of surface velocity is considerable with the wind up stream, while it is accelerated with the wind in the other direction. Thus it seems strange that Magnus, in 1850, should have denied the existence of an action of this kind as a result of certain experiments upon a jet of water. Viktor Von Lang, however, found by causing the jet to flow through a tube, the sides of which it did not touch, that the friction was so great that the air seemed to adhere to the surface of the jet. An extremely interesting and important case of the friction of gases on liquids, mentioned by Clerk Maxwell in his book on "Heat," is the case of rain and mist. In this case a drop of water falling through air one thousand times rarer than itself, or about the density at the height of an ordinary cloud, would fall $\frac{8}{10}$ of an inch in a second if its diameter were $\frac{1}{1000}$ inch. If its diameter were $\frac{1}{10000}$ inch, it would fall only one hundredth of its former rate, or half an inch a minute. A cloud of particles of this size would fall so slowly as to appear stationary. Thus it is on account of friction that clouds appear to remain suspended in the air, and that particles of dust, thrown up by volcanic agency or derived from meteoric sources, take so long a time to settle down.

Such are a few of the multitude of facts which might have been brought forward on the subject of fluid friction; but we must conclude this lecture with the consideration of a similar question to that at which we finally arrived in the first lecture, and endeavour to give a brief answer to the question, "What is the nature of fluid friction?"

In the first place, it must be remembered that there is an essential feature of resemblance between liquids and gases, which is, at the same time, the point of distinction between solids and fluids. In the case of solids, an alteration in form is only produced by stresses which exceed a certain value, and this is the case no matter how soft the solid may be. In the case of liquids and gases, a stress, however small, will cause a change of form, the extent of which depends upon the time of action of the stress. Thus we arrive at a definite mode of measuring the resistance to change of form of a fluid. Suppose one layer in the fluid to be in a motion with a velocity, V, relatively to another imaginary layer at a distance (d) from it. Then if the intermediate fluid is in motion with a velocity proportional to its distance from either layer, there is a separation of the contiguous particles at a rate which increases in the proportion $\frac{V}{d}$. Now the frictional resistance to this change is, in the case of fluids, measured by the area of the layers multiplied by this rate of increase, so that we may express the magnitude of the resistance thus—

$$F = \kappa A \frac{V}{d}$$

when $A =$ area of either layer.
$\kappa =$ a suitable co-efficient.

Thus for air the value of the co-efficient has been found to be—

$$\kappa = \cdot 000{,}000{,}0256\ T.$$

where $T =$ absolute temperature F.°

and the units are in lbs., feet, and seconds for water at 77° F.

$$\kappa = \cdot 000{,}00191$$

—(Piotrowski, quoted by Unwin).

The above co-efficient is called the "co-efficient of viscosity," and the the property of the substance by which the resistance is caused, is called its "viscosity."

I have hitherto carefully avoided the use of this word, which has here a definite meaning, although the highest authorities employ it as synonymous with fluid friction. Thus Clerk Maxwell says, "All fluids are imperfect, and exhibit the phenomenon of internal friction *or* viscosity by which their motion, after being stirred about in a vessel, is gradually stopped, and the energy of motion converted into heat." ("Theory of Heat," p. 96). Mr. Willam Crookes says, "By the viscosity *or* internal friction of a gas is meant the resistance which it offers to the gliding of one portion over another." ("Phil. Trans.," part ii, 1881, p. 388). Rankine does not use the word viscosity, but says, "Although the particles of fluids have no transverse elasticity, it is certain they resist being made to slide over each other, and that there is a lateral communication of motion amongst them ; that is, that there is a tendency of particles which move side by side in parallel lines to assume the same velocity. The laws of this lateral communication of motion *or* internal friction are not known exactly, but its effects are known thus far—that the energy due to the differences of velocity, which it causes to disappear, is replaced by heat in the proportion of one thermal unit (F) for every 772 foot-pounds of energy, and that it causes the friction to take effect, not merely in retarding the film of fluid which is immediately in contact with the sides of the channel, but in retarding the whole stream." ("Applied Mechanics," p. 586). Thus it is evident that the term internal fluid friction completely expresses the general phenomenon of resistance, and it would seem desirable to employ the word viscosity in a more limited sense, as the measurable resistance between parallel layers, as, for instance, Clerk Maxwell himself does in giving the following definition :—"The viscosity of a substance is measured by the tangential force on the unit of area of either of two horizontal planes at the unit of distance apart, one of which is fixed, and the other moves with unit velocity." ("Theory of Heat," p. 298). The term fluid friction could thus be used to denote all resistances including those caused by eddying motion. This I understand to be the view held by Professor Unwin.

None of the foregoing passages, however, attempt to explain the ultimate cause of the resistance, and such explanation is only possible upon some hypothesis of the constitution of matter. The molecular theory enables definite reason to be given which is set forth by Maxwell for the case of gases.

The molecules of gases are supposed to be in a state of continual agitation, and pass with great velocity from point to point. It is only when two gases chemically different are placed together that we can trace the passage of molecules in their diffusion, as it is called, of one gas into another. This diffusion is always going on in a single gas, only it is impossible to trace the progress of the molecules because they are all identical. Maxwell explains the friction of gases on the molecular theory thus :—"Particles having the mean velocity of translation belonging to one layer of the gas pass out of it into another layer having a different velocity of translation, and by striking against the particles of the second layer, exert upon it a tangential force which constitutes the internal friction of the gas. The whole friction between two portions of gas separated by a plane surface, depends upon the total action between all the layers on one side of that surface upon all the layers on the other side." ("Phil. Mag.," vol. xix., p. 31.) Elsewhere ("Theory of Heat," p. 323) the same author says, "It appears, therefore, that diffusion, viscosity, and conductivity of heat in gases, are related to each other in a very simple way, being the rate of equalisation of three properties of the medium, the proportion of of its ingredients, its velocity, and its temperature. The equalisation is effected by the same agency in every case, viz., the agitation of the molecules."

The frictional resistance of liquids may be accounted for in a similar way to that of gases, though with them it must be confessed that there are considerable difficulties in the way of accepting an explanation of the above simple kind. Such explanation must take account of the property of adhesion in liquids —and possibly also in the case of gases.

Even the hypothetical explanation in the preceding paragraph does not completely answer the question, "What is the nature of friction ?" We have seen in the statement of both Rankine and Maxwell that all the energy of motion is converted into heat, and that the internal friction is the agency by which this is done. The grandest generalisation of modern times, viz., the mechanical theory of heat, rests upon this supposition, and the mechanical equivalent of heat was determined by Joule by means of paddles which were turned in a vessel of water by falling weights, the temperature of the water being ascertained for a given amount of work done by the weights. The fact that the molecules are made to take different velocities in passing from one layer to another of the moving gas, does not of itself account for the rise of temperature due to friction, and we may suppose that the molecules themselves are capable of acquiring internal energy by virtue of a relative motion of their own parts, in addition to the increased energy of translation, and that the ultimate cause of frictional resistance is the absorption of energy by individual particles of the fluid. This, however, was exactly the point at which we arrived in the case of solids, and further than which we could not go; and we see that all substances, solids, liquids, and gases have one common property in the capability of absorbing energy in the form of mechanical motion, which energy is converted into an equivalent amount of molecular motion of their internal parts. As in the case of solids, we have therefore, in the case of fluids, arrived at a point in the explanation of the nature of friction at which we must await further advance in our knowledge of the constitution of matter itself.

ADDITIONAL LECTURES.

JAPANESE ART WORK.

By Ernest Hart.

Lecture II.—Delivered May 11, 1886.

These lectures are, as you know, intended rather as a running commentary on the collection of the works of the past masters of the arts of Japan, which, at the request of our Council, I have placed on view in the library of the Society, than as a systematic treatise, even in outline, on the subject. As time is short and the arts are long, I occupy the brief hours allotted to me rather in filling up gaps in the available literature on the subject, and in illustrating the character and history of the class of objects contained in this collection, than in travelling over ground already well-trodden, or referring to the history of certain arts of Japan, not easily represented in European collections, or already well-studied in available books. Hence, while not altogether omitting to refer to the larger wooden sculptures and to the bronzes of ancient Japan, I mentioned them only cursorily in my last lecture.

I have been asked to say a few words as to the smaller hieratic and domestic bronzes before passing to the proper subjects next on the programme—lac and faïence. I can do so but very briefly. Of the great Buddhist bronzes of monumental size, the Buddhist idols, such as those of the huge Yaku-Shi at Nara (7th century), the Buddhist Trinity at Nara (of the 18th century), of the colossal Daibutsu at Kamakura (of the 13th century), and of the great Buddha of Meguro (of the end of the 18th century), now in the fine collection of M. Cernuschi in Paris, I can only speak to recall to you the admirable chapters in Reed, Gonse, and Anderson, which deal with the subject, and to recommend a visit to the rich collection of Buddhist images and bronzes with which M. Cernuschi has generously endowed the fair city of Paris.

Of minor bronzes of early date, exemplifying the smaller hieratic images, I show you here some very fine specimens remarkable for the characteristic calm and solemnity with which the early workers knew how to invest the objects of their worship. A very unique and interesting object is this bronze statuette, the sitting figure of a disciple or Rakan, with knees easily overlapping, and clasped by the hand in a singularly naturalistic style; a remarkable example, of which the date can be precisely fixed, for, unlike Buddhist bronzes in general, it bears an incised inscription at the back, which explains at length that it is a votive offering presented by the Nun Nioyé, assisted by other subscribers, for the dead soul of her father, Giokuho, to the Temple Ko-unji at Nagasaki, in the year 1653, the artist being Akahoshi Hachizayemon. This bronze has, as you see, an historic and peculiar religious interest, in addition to its value as a rare document in art. Many of the other bronzes are, you will notice, incense burners, or *koros*, and altar ornaments. Such are the set of three, Nos. 445-6-7, in the series of bronzes (catalogue, page 30), which are very good specimens of the favourite types of form for this set of fine bronzes — incense-burner, vase, and candlestick (the set known as San-gasoku). They are wax casts of the 17th century, and are what bronzes should be in patina, chasing, and finish, and will serve to put you on your guard against the mechanical copies now abundantly furnished with a false lacquered patina to hide the defects of quality in the material, and the want of skill and patience in the manufacturers, who under commercial inducements, have superseded the ancient race of artists in Japan. In bronzes, you need not be told that the tests of merit are the beauty, variety, and rarity of the patina, the grace and skill of the modelling, the *finesse* in design, and the skill shown in the wax cast. Every true artistic Japanese bronze is an unique work of art, a wax cast, of which, therefore, a mechanical series of copies cannot be made, the mould being destroyed in the casting; it is the individual product of the mind and executive skill of the artist who made it.

Among the most instructive and remarkable pieces in this collection — from which I have been at much pains to exclude all but works of undoubted originality and high artistic merit as well as historic interest—I would point your attention to the series of works by Tôun and Seimin—the master workers of Japan in bronze, who together with Joi, carried the artistic bronzes, *koros*, vases, fire-pans, &c., to the highest point. (Cat. p. 29, Nos. 3, 9, 12, 16*a*, 44, 51, 52, &c.) Their works are now few and far between. Note the beauty of modelling and chasing, and conscientious finish, and the rich and soft patina, and compare it with the dryness or dishonestly lacquered surface of most modern bronze. Note also the fine red patina and the expressive chasing of the 17th century Daruma (No. 2); the small ingots of gold worked into material of the little Chinese bronze of the 14th century (No. 3), of the rare kind known as Kindo; and the similar work of not less admirable quality by a Japanese artist, Harusada, in the 18th century (No. 49). How this was effected is difficult to conceive, looking to the great differences between the points of fusibility of gold and bronze. This is what you often see imitated by a little "lick" of gilding in imitation modern Kindo bronzes. It may interest you to know that in the collection from which I obtained the bronze (No. 3), there were several quite worthless modern imitations, which were quite as prominent, and appeared to be equally valued as this. So necessary is it that you should use your eyes, study good authentic pieces, and not rely upon mere names or delusive appearances. For examples of this very old Japanese bronze, having a most exquisite patina like that of the old Greek bronzes, I may refer you to the small mirror backs in green bronze, Nos. 53-6 (Catalogue, p. 30), which were sent to me by Mr. Wakai, and undoubtedly belong to the 7th or 8th century. Other instructive specimens which may serve as standards, are the 17th century vases, No. 32 with its difficult and rare red and green patina, the *repoussé* Hiroshima water-pot of the 17th century, No. 20, which belongs to the same series as the beautiful old Hiroshima writing-box which you will find elsewhere. The curious incense burner, known as a *Mawari koro*, which I show you, has another kind of interest. It is, as you see, a hollow ball, in pierced and chased white metal, 18th century work, and has inside it a cup for burning incense suspended on a universal joint, so that it can be rolled about without spilling its contents. This invention existed and was known to the Eastern races several hundred years before it was reinvented by Hooke for the benefit of Europeans, and is described in a book written upwards of six hundred years ago, known as "Sai kio Zakki"—"Record of the Western Capital" (Anderson). But I must proceed from these supplementary observations to my next section, the peculiarly Japanese art-work in lacquer.

JAPANESE LAC AND LACQUER ARTISTS.

"It has been with justice said," says Mr. M. Gonse, "that works in lac are the most perfect objects which ever issued from the hands of man; at the very least they are the most delicate. These productions have been for long ages, and still are, the glory of the Japanese. It is a national industry which is peculiar to them, and in respect to which they owe nothing to anyone. The singularity of the processes, the finish of the workmanship, the beauty and price of the materials, constitute lac a thing by itself in the artistic manifestations of the far East. The lacs of Japan enjoy universal celebrity; they are the most exquisite cabinet objects which can delight the eye of a collector."

"Lac" is the gum of the "urushi" tree (*Rhus vernicifera*). Each ten year old tree yields, by incision, two to three ounces of sap, and the process of extraction destroys the tree either in one or two years, according to the method employed. The finest lac comes from trees of great age, and is therefore the most costly; the branch lac is the finest, and dries into the most perfect transparency and hardness. Hence it alone was employed in the fine old works; but as each layer takes a month to dry, and as modern works are executed with the greatest possible rapidity, and durability is now-a-days a secondary quality, the finest lac has, since 1868, considerably fallen in price, while the inferior and more quickly drying lacs have risen considerably. In the older processes, the object to be treated with lac, either wood or metal, was first prepared. Hard and fine wood was selected, reduced frequently to extreme tenuity, and the framework prepared, the surfaces being polished, sometimes coated with a delicate layer of silk. The prepared and evaporated "urushi" gum was then laid on in thin successive layers, polished with charcoal and stone powder, and successive layers built up by a variety of processes, which will be found described in the reports of the Japanese Commissioners at the Paris and Vienna Exhibitions; in the valuable report of Mr. Quin to Parliament, published as a Blue-book in 1882; and in the works of Audsley and Gonse. The black stain was given to it by the use of acetate of iron; the red by vermilion, and a variety of other pigments. That which the old lacquer-workers of Japan aimed at as a material result was to produce a substantial product of great hardness, brilliant polish, resisting alike heat and cold, and durable for successive ages. This they achieved. The lacs of old Japan exhibited at the last Paris Exhibition foundered in the ship *Nil* on their way back; when rescued from the bottom of the sea, they were unharmed. The modern lacs of fine quality which went with them were reduced to pulp, or were in a hopelessly damaged state. The old lac was a product of patience, as well as of technical skill and artistic genius. Each layer would need twenty to thirty days at least, sometimes two to three months, to polish, dry, and harden, and the whole work went through twenty to forty processes. A fine work was the product of two or three years. Modern lacs are apt to be made with new lac, diluted with large quantities of oil to make it work easily, and often thickened with farina, or other powders; hence they warp, tarnish, blister, and crack as years, or even months, go on. Our knowledge and appreciation of Japanese lac stands on a very different footing now to that on which it occupied prior to 1868. Not only was the production of artistic objects in lac an art exclusively practised by the Japanese, but practised by them exclusively for themselves. The exportation of lacs was for centuries rigidly prohibited. The Dutch traders who in the 17th and 18th century had a limited monopoly from their little settlement in the harbour fort of Deshima for the export of so many shiploads of "Japan china," were prohibited from purchasing lac. Out of a year's cargoes of hundreds of thousands of pieces of the Imari china manufactured for them, and sold in Europe, only a few stray pieces of lac were to be found, as the existing catalogues show, and those we now know to have been of a third-rate order. But any piece of China lac, as it is called, was then naturally a great curiosity, and sold at immense prices. We see the quality in collections such as those of Marie Antoinette at the Louvre (the finest), or the Hamilton collections, or the collection at the Hague, all once considered superlatively fine, but now that we are in possession of so many of the fine, though much smaller, lacs of the old Daimios, they cease to have either value or artistic interest. We are familiar with the old lac cabinets and screens of some English and Continental palaces and chateaux; heavy boards with a poor coating of black lac of inferior quality and little transparency or polish, and decorated with Chinese landscapes, pagodas, and other subjects, raised in gummy ill-defined reliefs, and gilded on the surface of the reliefs, or coarsely incrusted or inlaid with large scales of mother-of-pearl. Sometimes the landscapes are European, from illustrations furnished by the Dutch traders. These were rarities in Europe in the 17th and 18th centuries, but are merely specimens of very poor work, executed for a commercial purpose, for sale to the outer barbarians, and designedly of very inferior quality and workmanship, like the cottons, knives, and beads we in our turn send to the utter barbarians of Africa and China. Owing to the tradition of the high value once assigned to these or to their rarity, and to the fact that even these were beyond the resources of existing European technical workers, and owing also to the fact that immense prices were paid for them, these old Japan lacs are still the subject of a worship which has no longer any *raison d'être*, and sometimes realise immense prices, out of respect to their former rarity and *quondam* value. They are, however, in reality very mediocre productions, and now that we are in possession of the exquisite old Daimio lacs, they must sink, sooner or later, into a deserved obscurity. That which we appreciate now in lacs is the hardness of polish, the transparency, the perfection of surface, the slow and subtle processes by which the picture contained in the layer of lac is built up, as the whole mass is formed month by month, in the successive strata; the subtle and various tones of gold employed in fine gradations and at various depths; the accurately drawn lines; the skill with which enormous difficulties of technique are overcome, the grace and accuracy of drawing, the patience and self-sacrifice with which marvels of technical and artistic skill are produced with unobtrusive effects on an *inro*, or inside a writing box, or on the angles, and on the inner curves of a perfume box. Only those who understand the sharpness of the oft-repeated processes, who understand the difference of decorating a surface once for all from that of building up a design in a resinous and slowly drying material in layers; or who can appreciate the difference of working on the flat on a large scale, and working with the utmost minuteness in successive layers of a transparent material on concave surfaces, and at angles, will duly estimate the masterpieces of the great workers which I have the privilege of showing to you to-night. They require mostly to be examined individually with a magnifying glass, to see how patience has gone hand in hand with genius in producing them.

The published accounts of the art of the lac workers in successive ages in Japan, and of the different masters and schools, are very insufficient, and I find that English collectors have hitherto been guided chiefly by the superficial beauty of objects in lac, and very much, I am afraid, also by the amount of gold on them, and have had little care, probably because they have had few means of discriminating either the periods, masters, or schools. I am not aware of any English collection in which any sort of discrimination of the sort has been even attempted, and it is painful to see the jumble in cabinets of men of taste of quite worthless but showy imitations, with here and there the genuine work of a great master. I hope I may not be thought presumptuous in making these observations. I may, perhaps, disarm criticism on that head to some extent, by saying that I am only describing the state of mind and amount of knowledge with which I myself first began the study of lac, and that I have been rather shocked to find of how very inferior an order and very mixed character, and how chaotic and imperfectly representative, are most of the existing collections of lac in this country.

As I have said, in respect to metal work, the opportunities for collecting these unique works of a marvellous art and a great civilisation are rapidly passing away. It is lamentable to find how excessively poor are the lacs at South Kensington, which may be said indeed, in respect to this most fascinating and important art, to have—so far as it has any influence—one which is either null or wholly misleading. Nor am I aware of any collections in any art museums throughout the country which are capable of affording any instruction to the student of lac, or which will in any way bear comparison either with such a collection as that which I show you to-night, or as several of those which exist in private hands on the Continent. It seems to me greatly to be regretted that, with the opportunities which our large intercourse with Japan affords, with our large national and private resources, and the real love of art which exists in this country, our possessions of these art treasures should be so scanty, or ill-chosen, or ill-classified. The first step towards the possession of such a collection as is required is to establish the history, to define the schools, and to critically study and identify the masters.

This I will attempt for you in necessarily brief and hurried outline. That which has hindered, perhaps more than anything else, the advance of collections of old lac, as of the work of the historic artists of Japan generally, is the want of these available data, and the absolute ignorance of the subject in the case of a great majority of dealers, who are incapable of distinguishing schools or masters, and who, unawares, represent as fine lacs perfectly worthless modern imitations which have only a superficial resemblance to them.

Historical Notes on Japanese Lac.

Japanese history records the name of Nuribene-muraji, under the Emperor Koan, 392 B.C. That name signifies "director of the administration of lacs," which sufficiently proves that lacqueurs existed in Japan before it had any communication with China. It is, therefore, inexact to allege that lac was introduced into Japan from China, as some archæologists, too Chinese in their predilections, have assumed. The earliest specimens of lac still preserved, of which the date can be ascertained, belong to the Emperor Shômu (724-48).

Art lacs are comprised under various technical categories, and their domination in Japan differs according to the epochs of history.

The history of lac, like the history o Japanese art generally, may be divided into periods as follows:—

(1.) Shomu-Jidai, or Jodai; lacs from the reign of Emperor Shômu (724-48) to the end of the 8th century.

(2.) Kamakura-Jidai; lac of the period of Kamakura, from the 12th century, when the first Shogun Yoritomo was installed at Kamakura.

(3.) Yoshimasa-Jidai; period of the Shogun Yoritomo; 15th century.

(4.) Hideyoshi-Jidai; the period of Hideyoshi; end of 16th century.

(5.) Tokugawa-Jidai; period of the dynasty of the Tokugawa; 1603-1867.

I. In the 8th century, lac assumed a very complete development, and in the 10th century it attained high perfection. Pictorial decoration was applied to lac, and designs of great beauty were produced. The fashion of mounting the borders of objects in lac in silver, tin, &c., became general. The objects in lac of this period are, by Japanese connoisseurs, classified as follows:—

(1.) Makkireo (which signifies inlaying

of articles with gold). In this lac the successive layers were carefully polished, so that the designs appear in the substance of the lac, which presents a perfectly smooth surface. This polished lac, with designs presented in the depth of the material, is really lac of the very highest quality and greatest difficulty of execution. Strange enough, and probably because the *main d'œuvre* and the essential qualities of fine lac are imperfectly understood, works in smooth polished lac are, in this country, very inadequately appreciated, and inartistic preference is given to highly gilded works, in which the designs appear in relief, a wholly irrational and inartistic preference. Of authentic works of this kind, of the 10th century, I know of only one piece, which is in the possession of M. Gonse. It alone suffices to show the exquisite perfection of the works of the 10th century.

(2.) Hiomon (which signifies flat or surface decoration). In lacs of this description, plaques of gold or of silver were incrusted in the lac on the same level with the smooth surface.

(3.) Heijin (meaning flat powder). This variety belongs to the kind of lac known as nashiji, but the grains of gold powder are much larger than those in nashiji in general, and the powder is obtained by filing gold.

(4.) Raden, or incrustation of mother-of-pearl, which is inlaid smoothly and level with the surface of the lac in the same manner as with Hiomon.

(5.) Besides these varieties there are lacs encrusted with hard stones; specimens of all these varieties of lac, belonging to the 10th century, exist in the temples of Todaiji and Horiuji, in Nara, but authentic examples are exceedingly rare in Japan, and in Europe not to be found.

II. The civil wars of Gempei having affected injuriously the art of working in lac, it did not again rise into prominence until the foundation of Kamakura. The Kamakura lacs were made under the patronage of the Shogun Yoritomo, and Masago, his wife. Although under the Emperor Konoyé (1142-1155) objects in lac for the use of the Court were, we know, richly decorated, still it is to the Kamakura period that fine lacs known as Makiye apply. (Makiye signifies the design obtained by powderings of gold—or, briefly, a powdered design.) The objects of this epoch are classified as follows:—

(1.) Ikkakidzi, lac thickly powdered with gold, with incrustation of mother-of-pearl, or of plaques of gold.

(2.) Raden, that is, flat incrustation of mother-of-pearl on powdered gold background.

(3.) Hiomon, or flat incrustations with gold on a coloured or black background.

(4.) Makiye, gold powderings, principally of the variety known as the Togidoshi-makiye or polished lac.

(5.) Incrustations with hard stones.

(6.) Kamakura bori, of which the wood is incised and gilded, and lacquered in black or red. The specimens preserved in the temple of Hachiman, and of Tsurugaoka at Kamakura, belonging to this period, are described as being of the highest perfection. The marvellous gold lacs incrusted with mother-of-pearl by Korin, which I shall presently show you, are nothing else than the lacs of Kamakura regenerated under the artistic genius of Korin.

In my collections you will find various specimens of old lac, but one box especially, in the polished lac decorated with chrysanthemums in gold on a black back ground, is an authentic specimen of this Kamakura period.

III. With Yoshimasa-Jidai, or Higashiyama-Jidai, we enter upon a highly artistic period. Higashiyama Yoshimasa having been himself an artist and a great promoter of Japanese art. The application of freehand drawings to lac in the 10th century was restricted to a very narrow conventional limit of subjects, and this limit was made still more narrow because the Kamakura style was dominated generally by purely ornamental designs. Yoshimasa not only revived the art of the 10th century, but he caused various pictorial subjects to be applied to the decoration of lac, while under his auspices, new ornamental designs were invented, and the old were often much refined. The lacs of this period, of which I am able to show you a splendid specimen, are unhappily, but naturally, excessively rare. They find, however, a parallel in the finest lacs of the 17th century, when luxury and artistic refinement prevailed throughout Japan, and which was the period at which all the ornamental arts flourished in their highest perfection, and when the great masters were welcomed as the friends of the shoguns and princes.

IV. The period corresponding to the Taiko-Hideyoshi, who died in 1598, was a period of interregnum. The anarchy of the 16th century had suppressed the development which the arts had already reached in the 15th century, and, leaving the artist without encouragement, had broken up the most celebrated schools owing to the ravages of incessant war. When Hideyoshi established himself at Osaka, he gave a new impulse to working in art, and restored this branch, which was on the point of disappearing. These objects of the 16th century are of a mixed character; here and there may be found a *chef d'œuvre* and sometimes very mediocre, though authentic works. This state of things continued to the reign of Tokugawa Iyeyasu, who died in 1616.

V. The reign of the Tokugawas inaugurated a period of the highest perfection. The objects belonging to this period are rich, elegant, pleasing to the fastidious eye, and artistic. They may be divided into three periods. The 17th century in Japan, as in Europe, was a period of the most refined, elegant, and luxurious art.

(1.) Sandai-shogun, the period of the third shogun of the family of Tokugawa, called Iyemitsu, who reigned from 1623 to 1649. It was this Shogun who caused to be constructed the splendid temples of Nikko, the hexagonal temple of Shiba at Yedo, profusely decorated with gold lac, &c.

(2.) Joken-in-Makiye. Under this name are designated chiefly the lacs which were made during the period known as Genroku (1688-1703), under the 5th Shogun Joken-in, who reigned 1681 to 1708. These 17th century lacs preserve the archaic taste, while they are at the same time elegant, delicate, and full of refinement.

(3.) Bunkio-in, the 11th Shogun of the Tokugawa, who reigned from 1787 to 1837. The lacs of this period are very skilful. The subjects with which they are decorated are varied, lively, and artistic, but they belong to a period of relative decadence. The very perfection of lacs is to be found in the 17th century, and the early part of the 18th, putting aside the rare specimens of the very highest quality of the 10th and 13th centuries, of which, as I have said, specimens may practically be considered to be unattainable to European collectors, at any price which they would be willing to give. The few fine specimens which exist in Japan, elsewhere than in the treasures of the temples, are held at enormous values. To study, however, individual pieces of lac, we must now acquaint ourselves with the schools of artists in lac which arose during the period of the Tokugawas. We are perfectly familiar with their history; we can identify and classify their works, and in the catalogue which I present to you of the collection on view in the rooms of the Society of Arts, each object is classified under its school, and, where possible, identified as the work of its master. In many cases, especially in the cases of inros, the master signed his work, but for other objects, especially ordered by the damios or the shoguns, it was not the etiquette to affix such signatures. While, therefore, you should learn to distinguish schools and identify *main d'œuvre*, and also to read and identify the signatures, you must not consider that either one of these accomplishments by itself suffices, since many of the finest works are necessarily not signed, and only a part of those that are signed afford evidence of being authentic, for various reasons which I may have time to explain to you later on. In Mr. Hayashi I have had the good fortune to find a Japanese expert of delicate, exact, and fastidious taste, and of great erudition, who has not only studied all the available native literature, but having, in the series of years, had nearly all the finest pieces in Europe pass under his hands, has supplemented his learning by great experience and critical study. Hence, in any doubtful cases, I have rigidly excluded pieces which were not evidently authentic, and which he could not identify.

THE SCHOOLS OF ARTISTS IN LAC.—THE SCHOOL OF KOYETSU.

Honnami Koyetsu, of Kioto, was at once an artist, a caligrapher (a fine art both in China and Japan, where writing was executed with the brush, and beautiful writing was a high accomplishment), ceramist, and lacquerer. He flourished at the end of the 16th century, and the beginning of the 17th century, and was an extraordinary artist. Under his influence the celebrated Korin formed his characteristically bold style. His school divided itself under two different styles, each constituting a separate school.*

(1.) The school of Korin, who, following the impulse of certain of Koyetsu's works, created a genre in lac known as the "style of Korin," and marked by singular breadth and nobility of design and character, having peculiar tints of yellow and green gold, and encrusted with bold designs in tin and mother of pearl. The works of Korin have for me a peculiar fascination, and I have succeeded, with great difficulty, and by the aid of Mr. Wakai and Mr. Hayashi, in bringing together from various sources in Japan and Europe a series of the finest works of this rare and original master, which I value beyond measure. They are, as a whole, an unrivalled series, and represent a master who created an epoch in Japanese art (and who influenced his illustrious brother Kenzan, the great ceramic artist and painter, see Lacs, No. 30), and whose genius, as shown in his pictures and designs, is not less remarkable than in his lac, which inspired so many followers. (I particularly invite your study of the Suzuribakos, or writing boxes, by Korin, Nos. 2, 3, 6, 7, 8, and to the Inros, Nos. 324, 325, 326, 328, 332, and 333; also to the letter-press by Korin, No. 31, a magnificent work of Korin, which Mr. Audsley has figured in the ornamental arts of Japan). Ogata Korin was born at Kioto in 1661, and died in 1716.

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* See Catalogue, Lacs, No. 1 and Inros Nos. 316 and 319.

(2.) The second school which was formed under the auspices of Koyetsu was that of Tsuchida Soyetsu. Soyetsu gave himself chiefly to the more delicate style of work inspired by the master; but, just as Korin began with the most delicate work (see Catalogue, lac No. 16, page 11), so Soyetsu made sometimes inros of the most characteristic largeness and boldness of design. Of this you will find examples in this collection.

THE SCHOOL OF SHUNSHÔ.

Yamamoto Shunshô was a pure artist in lac at Kioto about the middle of the 17th century, and executed the most refined polished lacs (*lac frotté*), Makiyé and Jogihashi makiyé. The *lacs frottés* are the final word of refinement and perfection. This collection possesses some exquisite specimens, which are duly numbered in the catalogue. The mirror brightness, the solidity, and spotless perfection of the lac, the delicacy, variety of tone, and refinement of colour, and the unsparing labour bestowed on the decoration of the inner surfaces and angles, make the lacs of this great master very precious in the eyes of the connoisseur. The sparing use of gold, the black lac background, and the absence of relief, have caused them to be less remarked by English collectors than the glittering, coarser, and more evanescent "gold lacs" of inferior artists, who have known how to flatter a relatively vulgar modern taste for show and gilding. The Japanese artists, both in metal and lac, had a proverb which may be commended to modern use. "He who works in gold puts his brains into the melting pot." Their finest metal work was in iron, and their finest lacs in black and delicately tinted "urushi." They dignified the material in which they worked, and did not rely upon its brute costliness.

The successors of Shunshô continued to sign his name to inferior works. They transported the atelier to Nagaji in the province of Owari.

THE SCHOOL OF KOMA.

There were early artists who founded this school in the time of Yoshimasa, but we are not able to identify their works. At that date the division of schools was not established, or the traditions have been lost.

The work of Koma Kiuhaku, who was called to Yédo as the official artist of the 3rd Shogun, and created the school we know at the commencement of the 17th century, is always of the most refined character and beautiful quality. His mirror black cannot be surpassed; and the fine delicacy of the old lacs from the *atelier* of Koma, and the exquisite perfection of the delicately traced gold reliefs, give them a *cachet* which is easily recognised after studying some of his authentic works. His son, Yasutaku (see Lac 81, p. 14), produced some work not sensibly inferior; but the products of this atelier fell off, until it was revived in the 18th century, by Kuansai, under the patronage of the Shogun Bunkio-in, who produced characteristic works of the highest merits. (See for examples Inros, Nos. 395, 402, 418; lacs, 73, p. 14; sake-coupes, 1 to 3, &c.).

THE SCHOOL OF KAJIKAWA.

Kajikawa Tomohidé, commonly known as Kûjiro, or Kajikawa the 1st, was an artist in lac, who produced pictorial effects in miniature worthy of the brush. To inspire yourselves at once with his qualities, examine such a piece as the little perfume-box by Kajikawa, decorated with the portrait of Hitomaro, an authentic specimen, which is the *ne-plus ultra* of refinement, and speaks for itself. The variety of tone of gold and these gradations of colour, this resource and variety of artistic effect, were the special gifts of Kajikawa, and became a tradition with the ablest of his successors. It was a kind of lac which made heavy requirements of time, talent, and conscience. Hence Kûjiro and his successors were always the artists of the Court of the Tokugawas, ranking in this line with the Kanos in painting and the Gotos as metal workers, the Kajikawa continued to use his seal, and the pieces so signed are relatively numerous. They are rarely other than good, but are of very various degrees of merit, and sometimes of merely secondary quality, and you must use your trained judgment, after study of the test, to distinguish the relative dates and grades of merits. With practice and conscience this is not difficult.

THE SCHOOL OF KOAMI.

Koami was an artist name also already celebrated in the fifteenth century. But the first artist of the school whose merit we can mark, and whose work we can distinguish, was Koami Nagataka of the seventeenth century, who produced the most delicate and brilliant work. I show you a suzari bako or damio writing box by Koami Nagataka, which is of its kind unsurpassable, and is a rare possession. I do not know any other specimens of his work in this country. He was celebrated also for his Hiramé and aventurine lacs, worked with gold powder of large grain.

THE SCHOOL OF YOSEI.

This school was distinguished especially for the *Guri* or *tsuishu* lacs, vermillion on the surfaces, and worked in layers of different coloured lacs, of which the cut edges show in looking into the deeply chased scroll with which the surface is incised; and the violet or black lacs built up similarly, and chased in the whole thickness of the lac, known as tsui-koku, rare and costly varieties of lac, represented in the collection before you by the superb cabinet No. 181, and by various inros and boxes. This is a kind of work of very laborious and costly kind. It is modest in appearance, as it is only on examining the cut edges of the incised patterns that you can perceive the slow building up of twenty or thirty layers of variously coloured lac by which the effect is produced. I asked a celebrated Japanese expert in lac how long it would take to produce such a cabinet as this, and at what cost he could take an order for a similar one. He said that such work was not done now, but it could be. It would require a year and a half to two years to build up and properly harden and work the successive layers of lac for a work of this size and importance, and the mere cost of production would be £120, without the *cloisonné* enamels and fittings (which in this case are of the seventeenth century, and singularly fine). Yosei worked about 1650-70, following, however, the much earlier traditions of Monuyu. The Chinese produced the tsuishiu or carved red lac in the Kienlong period 1736-1795, but I consider the old Japanese tsuishiu much superior in richness of colour, beauty of surface, and design. The pupil of Yosei was Yomo, who produced some very fine work; afterwards it was continued by others, but fell off very much in quality and artistic merit. Zokoku revived the merit of fame of this school in the 18th century, and works by him, like those by Kuansai and by Yoyusai, always do honour to the ancient art of the lacqueur. Their work is scarce, but by the kindness of my Japanese friends, and by rare good fortune, which has given me the pick of several important collections privately dispersed of late years in Japan and Europe, I have been able to secure some characteristic specimens of the work of each of the leading masters whom I have named. In this collection you will find inros and a wonderful lacquered dish by Zeshin, and two rare albums painted by him in lac, from which Mr. Anderson has selected one of the illustrations of his great work on "The Pictorial Arts of Japan."

SCHOOL OF SEIGAI.

Seigai Kanshichi was an artist who shone towards the end of the 17th century; he excelled in the production of green lac, which he was fond of decorating with conventional waves. I have no specimen, and know of none in Europe. One is, I believe, in the possession of Mr. Wakai, which formerly belonged to Yoyusai. The imitators of Kanshichi were not very successful. Zeshin, who still lives but has ceased to work owing to his great age, who springs from the school of Koma, is the most marvellous worker in coloured lacs since Kanshichi, but Zeshin may almost be considered as an independent master, such is the variety and sometimes the eccentric originality of his genius.

THE SCHOOL OF RITSUO.

Ogawa Ritsuo, a samurai of Kuwana, in the province of Ici, renounced the career of arms to give himself up to art. He was born in 1662, and died at Yedo in 1746. He was a painter, sculptor, faïencier, and lacquerer, not to mention that he had been renowned as a tactician and swordsman. The lacs of Ritsuo are from his own designs, while most of the lacs of the artists whom I have mentioned, except Korin, have habitually worked from designs painted by pictorial artists more or less celebrated; or reproduced from well-known celebrated drawings of traditional renown and well-known popularity. The lacs of Ritsuo frequently have incrusted on them decorations in relief, in faïence, ivory, pearl, tortoise-shell, metal, and gilded wood. It is work of very original and artistic effect. Like a true artist, he scorned precious metals, and produced the most striking decoration with materials which had no intrinsic value, and owed everything to their artistic merit. This splendid writing-box and manuscript case, encrusted with an elephant and other decoration in enamelled faïence, does not belong to me, but I am enabled to show it to you by the kindness of Mr. Hayashi, to whom it has recently been forwarded by a Japanese noble. I am not surprised to learn that these two masterpieces by Ritsuo are valued at £250. In my collection are many fine but smaller works by Ritsuo, in lac, porcelain, wood-carving, and painting. He is one of the epoch-making geniuses of Japan, whose authentic handiwork serve as standards, and form the land-marks for collection. His best disciple was Hanzan, whose brilliant handiwork is before you, and since him, Kenya. (Appendix, Lacs, Nos. 10, 40, 71, 165, 176, and various Inros.)

DESCRIPTION OF THE VARIETIES AND DESCRIPTION OF TECHNIQUE.

Nearly all the objects in lac shown are made, as you see, by the use of lacquer laid on in successive layers, and hardened in damp pressure, the basis of these objects in lacquer is one or other kind of selected woods, chosen for their capability of receiving a finely polished surface, and as not being liable to warp. The best woods are the woods known as the Honoki (*Chamæroparis obtusa*), the Kiri (*Paulownia imperialis*), the Keyaki (*Planera japonica*). "The first-named," says Mr. Audsley, "is a favourite, and very suitable wood for boxes and panels, and all kinds of cabinet work, chiefly because it admits of a high finish, and is not liable to warp. The second has been almost universally used for lacquer sword sheaths, and other fine works requiring tough wood. The third is a smooth-grained light wood, commonly employed in the construction of large boxes; and the last is most suitable for turning and other ornamental operations." The cabinet work is, as you will see, in itself marvellous. In centuries, these frail medicine boxes, made in small compartments, have not warped; and they are made with such perfection that, although of small dimensions, and oval-shaped, in many of the finest specimens the parts are interchangeable, and one piece will glide smoothly on to another either back or front, the top piece fitting on to the lowest with as much accuracy as if they had been made in Mr. Whitworth's machines. This octagonal cake box, which I show you, and which is a piece of the 17th century, illustrates well the singular beauty and perfection of their cabinet woodwork.

The first operation is to make the surface perfectly smooth by rubbing it down, and sometimes all the soft wood is carefully rubbed away so as to leave the hard veining of the wood apparent, which is utilised as a natural decoration. Of this you will find in this collection numerous examples. Successive coats of perfectly transparent varnish are then overlaid, and on this, frequently, decoration in raised gold or coloured lacquers. (The smooth surface is obtained by priming.) This is now dried in the damp press, the joints are filled, and the object again placed to dry. The surface is once more rubbed down and covered with a thick coating of moist paste made with a fine burnt-clay powder. Successive layers of varnish are then laid on, time being allowed for them to harden and dry, and each in turn being carefully rubbed down to a glossy smooth surface by the aid of charcoal powder and other polishing processes. In all, for the production of a fine piece of lacquer ready for artistic decoration, no fewer than thirty-three distinct and successive operations are carried out, from the first priming to the final polishing of the lacquer with horn ash. Sometimes the number of distinct operations is from fifty-five to sixty; thus the amount of time necessary for a fine piece of old lac varies almost indefinitely from weeks or months to over a year. Mr. Quin estimates roughly the total minimum occupied in drying a piece of ordinarily good lacquer in the damp press to over 530 hours, divided into twenty distinct periods. This, however, is a minimum, and it is impossible to fix any limit other than that of the varied exigencies for the workman's amount of time spent on some of the finest pieces. It is of course understood that the cheap kinds of lac habitually put on this market do not undergo these variety of processes; for instance, in the lower grade of black lacquer work habitually sold in Europe, the article to be lacquered receives only a single coat of diluted lac coloured with lamp black, and a single good coat of the kind of lac known as Johana lac; while in many of the cases a coating of persimmon juice and lamp-black, or glue and lamp black, is altogether substituted for the real urushi juice. To produce colours in lac, various pigments are of course added to it, such as vermilion, chrome yellow, Prussian blue. It is only in the inferior modern lacs that oil is freely used, and the introduction of a liberal per-centage of oil greatly facilitates the manufacture; but in lac work, as in oil painting, it is the oil which, as the medium of the colour, is the great enemy of the work in respect to its durability, for the oil with age hardens and contracts, and the lac perishes, and the beauty of the work is destroyed. You know that the process of what is called restoration of pictures largely consists in nourishing the picture with oil. The great enemy of lac, as of oil pictures, is the oil, and it is lamentable that the use of oil has been so largely introduced to aid rapidity of the production of modern lac work. In the production of inlaid lacs of variegated colour the ancient artists of Japan were highly skilled, but owing to the extreme difficulty of working with the pure urushi juice, mixed with the variegated colour (an exceeding intractable material, and one which required infinite patience and skill to build up, layer after layer, a transparent fabric of really artistic effect) the specimens were rare and excessively costly, and the art but little practised. The difficulty was the greater because the urushi juice blackens by exposure to light in the first instance, and when employed the artist could only judge by special skill and experience of what would be the precise effect of colour when, by repeated polishing of successive layers, the ultimate colour would be developed after drying in the damp press and exposure to sunlight—a difficulty such as that which is well understood by European workmen in the treatment of enamels. An attempt was made about twenty years ago to revive fine inlaid lac in these variegated colours. Zeshin, one of the oldest, perhaps the last, of the lacquer workers of the old school of whose boxes and albums I have here some specimens, produced some of this work. Here is a plate made in the old style from the finest branch lac by Zeshin, and bearing his signature. You will see that he has, with infinite cunning, imitated the colour and patina of old bronze, and this plate is one which is particularly interesting as being perhaps the last work of the last worker of the good old school. Not that it is impossible to go on producing such work, but that the modern demand is for something which shall look like this, and be superficially painted to resemble it, without the need of going through these laborious processes, but also without their permanency. At the end of a hundred years we may prophecy that this plate will retain its pristine beauty. It would be hard to predict that of more than a small proportion of the work which is now being produced. Here also is a large box of which the interior is, as you see, composed in a variegated lac, giving the effect of finely coloured variegated marble, and externally its panels are chiefly in green lac, inlaid with decorated patterns in lac of various colours. This is a work of the same school. The Minister of Commerce of Japan, who is one of the few who is filled with patriotic enthusiasm for the perfection of the ancient work of his countrymen, and who desired to find the means of perpetuating it, employed for the last International Exhibition at Paris surviving workmen trained in the old traditions, who had been at work prior to the revolution of 1868, and who were willing, for the modest payments then current, to continue to carry out works of art on the ancient principle. This is one of their productions. It is, perhaps, not surprising that, even at a great sacrifice—at a price far below its actual cost of production—it found no purchaser, for alongside of much more showy modern work it seemed excessively dear. I have, happily, secured it for my collection, and with the history which I give you of it, it will perhaps attract your interest. It is the work of an artist named Notomi, who still lives, and who is of the highest skill. Mr. Notomi was paid for his labour for making this box 300 yen, or £60. What is generally known as gold lacquer is that which is most highly appreciated in Europe. In the finest varieties of the old gold lacquer, the basis is prepared in the same way as that described; first is built up the Honji, or original lacque base, by its twenty or thirty processes of successive overlaying of varnish, polishing and drying; then begins the decoration in successive layers in lac; to produce the desired effect a great variety of powders or scales, or thin leaf of gold, alloys, and silver are employed. Mr. Quin enumerates twelve sizes of powder; and it is to be observed that the Japanese artist used gold not as we value it so much, for its glitter, but for its colour. He used pure gold, or an alloy of gold with silver; a gold compound known as shakudo dust, which contained seven parts of pure gold, with three of fine copper powder, giving a metallic effect having a tint of pure copper; or gold mixed in various proportions with vermilion, giving the red tints or chestnut tints; or a black-coloured gold mixed with finely-powdered camellia charcoal. Sometimes scales of carefully selected green or crimson mother-of-pearl are incrusted. A panel shown at Kew by Mr. Quin has on it 110 specimens of these varieties of compound colours. In making the polished lacs, Hira-makiye or Togi-dashi, the preliminary stages of the manufacture of the lac base or Honji are gone through, and the design to be produced on the lac is then drawn on tough paper prepared with a size of glue and alum, and then with a fine rat's hair brush, charged with lacquer, the artist goes over all the ink outlines on the reverse side of the paper. The paper is then laid with the lacquer design downwards on the article to be decorated, and rubbed with a whale bone spatula, so that the outlines are transferred to the lacquer surface. Then begins the process of gilding. Those parts of the design which are to be brightest are gone over with a stiff lacquer, and sprinkled with fine gold powder; when the lacquer is fully charged with the powder and superfluous gold dust removed, the object is put into the press, the other outlines which are intended to to have a duller tint are then dealt with and again hardened. A new coat of urushi is now applied and again hardened. The whole design then appears in flat gold with the details first painted on with stiff lacquer in slight relief, for they have been twice coated and twice dusted. In drawing in the delicate designs, the fine brush charged with lac and gold for colour is held firm and steady, and the object to be lacquered moved with unerring accuracy, so as to produce the desired lines or shadings. This is a necessity of the stiffness of the urushi with which the pigments are mixed, and requires singular skill of hand. A further coat of urushi is applied and hardened, then the whole varnished surface is carefully ground down with fine charcoal. The surface is watched and treated during this polishing and grinding process to prevent the gold being accidentally reached and injured by the charcoal. It is once more coated with the urushi and once more hardened and dried, and this process continued until the final result is attained. This whole process is described in detail by Mr. Audsley, from whom I have taken this summary, and specimens, showing the principal stages of the manufacture, are to be seen at Kew. The greatest skill and care are required in the powdering, in the gradation of the effect, and in the colour of the powders, so as to give the perfectly pictorial effect in different coloured golds at different depths, which is attained in the finest of the old gold lacs; and it is worth your while examining carefully some of these fine polished lacs of the 17th century, such as the manuscript box No. 183, the despatch box No. 148, and the inros of Shunsho and Shlomli in my collection, in order to study the exquisitely artistic effect which is attained by these truly pictorial and artistic uses of gold as a means of tender colour in decoration, combined with durability and unequalled brilliancy of the cheap kinds of gold lac now made by thin dustings of gold on mixtures of lac, liquidified by the aid of camphor, and coloured with red oxide of iron. You will find abundant examples in all the shops, and, unfortunately, in many collections. The chief aim of most of the makers in the production of these modern lacs is to use as thin a lac as possible, as rapid processes, and as thin a layer of gold. To the eye superficially beautiful effects are produced, though the false glitter and coppery lustre reveals itself to the educated eye, even while the pieces of modern lac are for the most part like the fancy Sheffield razors, "made to sell, but not to last." I am sorry to say that the gold now largely used is a cheap compound imported largely from Germany, known as gold powder; and even fine tin and zinc powders are used in coloured powdered alloys, and a deceptive appearance is given by covering with lac to which colour is imparted by gamboge and other pigments, so that the tin and zinc seen through this medium have, to the uneducated eye, the appearance of gold.

In the gold lacs in which the pattern is in relief the skill of the artist is shown in the perfection with which he gets the varieties of relief, and in the accuracy with which he obtains definition of outline and perfection of curve. In the saké cups, for instance, which I show you of the School of Koma, with whirlpools of waves, of the 17th century, No. 1 to 3, p. 18, and in the writing-box signed by Shunsho, of the 17th century, with a landscape and fir-trees in gold relief, and in this long dispatch-box entirely in gold lac with a raised landscape, you will notice that every line is drawn with the utmost clearness, and that the surfaces and curves are as perfectly rendered in modelling as if the material were of a kind most easily worked, or as if they had been chased out of the solid instead of having been built up and polished in the manner described. This perfection of drawing and absolute sharpness of outline in all the lines and minute details is one of the best tests of the skill of the artist. In most of the showy modern lacs you will find a "gumminess," a want of definition in the modelling of the fine lines, and a clumsiness of outline and obliquity of edge, which indicates rapidity of work and want of that conscientious fidelity which characterises the finest old work, large pieces intended for merely decorative purposes, us to expect to have screens or huge bowls made in work as difficult and costly as the necklaces and bracelets which constitute the work of the jeweller in Europe.

But I must now turn from the fascinating subject of lacs to speak of the old Japanese porcelain and faïence.

Miscellaneous.

CARRIER PIGEON CONTEST AT TURIN.

The result of the carrier pigeon contest which took place lately has just been published. The birds were set at liberty in two batches, the first consisting of 280 pigeons, belonging to Florence, Collegara, Modena, and Reggio; and the second of 130 birds, from St. Ilario, Parma, Cremona, Piacenza, and Casalpusterlengo. The distances in straight line from Turin to these towns are as follows:—

	Kilometres.	English Miles.
Florence	318	197½
Collegara	265	164½
Modena	262	162¾
Reggio	238	147¾
St. Ilario	222	137¾
Parma	211	131
Cremona	185	115
Piacenza	160	99¼
Casalpusterlengo	156	96¾

In the first group, the gold medal was awarded to a pigeon from Modena, which had attained a speed of 56,073 metres (34·82 English miles) per hour, a silver medal to a bird belonging to the same town, which had attained a speed of 55,830 metres (34·67 English miles). A higher average rate was attained by the pigeons of the second group, the first, to which a gold medal was awarded, a speed of 62,337 metres (38·71 miles), and the second (a silver medal) a speed of 56·814 metres (35·28 miles). Diplomas of merit were awarded to the City of Modena, as showing the largest number of pigeons which had attained a rate of flight exceeding 35 kilometres per hour (21·73 English miles), and another to the Club of Pigeon Fanciers of the same town for the largest per-centage of birds which had returned home by 7 p.m. the same evening.

AGRICULTURE IN MAURITIUS.

For supplies of cattle and sheep Mauritius is entirely dependent on other countries, notably Madagascar, the Cape, and India; but fish abound in the surrounding seas.

So much of the agricultural area of the island is taken up with sugar growing, that small room remains for other branches of farming, hence much of the grain consumed by the inhabitants, especially rice, is imported. The raising of cereals, such as maize, millet, gram, dhal, and rice is attempted on a small scale, and yams, manioc, and sago have been produced in trifling quantities, but the total local supply of vegetable food stuffs is inconsiderable. Fruits, on the other hand, are cultivated to a large extent, and embrace apples, avocado pears, bananas, custard-apples, figs, guavas, the *litchi (Nephelium litchi)*, a delicious pulpy fruit from China, the *mabolo* (*Diospyros discolor*) of exquisite flavour but objectionable odour, mangoes, pine-apples of the choicest kinds, shaddocks, and tamarinds. Mention must also be made of the papaw fruit, from which, in this island and Bourbon, a passable *compote* is made. Spices, raised in small quantities, comprise betel, cloves, ginger, nutmeg, pepper, pimento, turmeric, and vanilla, pods of the last-named being sometimes exported. The date palm has become well established; so also has the coconut, whose oil is now shipped in thousands of gallons annually. Sugar is the all-absorbing object of culture, engaging the whole population, and affording an export value of about £3,000.000 a year.

General Notes.

King's College, London.—Special courses of lectures, commencing on October 25th, will be given at King's College during the ensuing winter session of the evening classes. The subjects will chiefly be treated with a view to assisting independent study, and the lectures have a similar scope to those delivered at the Universities. Each course will consist of not less than eight lectures, to be given on the same evening in consecutive weeks. Tickets, price one guinea for each course, may be obtained at the office of King's College, Strand, or will be forwarded on application to the secretary, J. W. Cunningham, Esq. I. "The History of French Literature," from 1815 to 1848, by Professor Moriarty, B.A.; Mondays, 7 to 8 p.m. II. "Iron and Steel," by Walter G. McMillan, F.C.S., (Demonstrator of Metallurgy, King's College, London); Tuesdays, 7 to 8 p.m. III. "The Geometry of Newton," by Professor W. H. H. Hudson, M.A.; Wednesdays, 7 to 8 p.m. IV. "The Roman, Etruscan and Græco-Roman Monuments in the British Museum," by Professor G. C. Warr, M.A.; Fridays, 6 to 7 p.m. V. Lectures on, and Readings from, the "Nibelungenlied," by Professor C. A. Buchheim, Ph.D.; Fridays, 7 to 8 p.m.

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Proceedings of the Society.

CANTOR LECTURES.

FRICTION.

By Professor H. S. Hele Shaw.

Lecture III.—Delivered February 1st, 1886.

The Mechanical Applications of Friction.

The difficulty of treating in a satisfactory manner the subject of the mechanical applications of friction, even when all consideration is excluded of those cosmical phenomena in which friction plays a part, arises not from any want of material but from the vast array of examples which present themselves. The numerous and divers purposes for which friction is employed, and the impossibility of dealing in this one lecture with more than a comparatively few examples, render it necessary to consider the nature of those applications with a view of arriving at some convenient kind of classification.

In the first lecture, we saw that the resistance of friction existed not only when the surfaces were actually moving over each other but when there was a tendency to motion Now the objects for which frictional resistance is employed are either (1) to prevent the relative motion of the surfaces, or (2) to take advantage of the results of frictional resistance when such relative motion actually takes place. Thus we have two classes into which the applications of friction are naturally divided:—

1. Where the resistance is sufficiently great to prevent the surfaces from sliding over each other, or where there is statical contact.

2. Where the resistance is accompanied by a sliding of the surfaces, or where there is contact of motion.

These two classes of applications may be sub-divided. The first includes (i) the case where friction appliances merely act to fasten or lock two surfaces of appreciable extent, and so prevent their relative motion; and (ii) that in which the motion is transmitted from one surface to another by means of a point or line of contact. The second may be subdivided according to the objects in view. These may be:—

(i.) To produce the molecular effects of heat and electricity.

(ii.) To obtain vibrations, such as occur in musical instruments, fog horns, &c.

(iii.) To effect a change of the surfaces in contact, as in the case of grinding and polishing.

(iv.) To absorb energy, such as takes place in the action of brakes, regulators, and appliances for measuring power.

The applications may, therefore, be stated thus:—

(1.) Resistance to friction (statical contact)—
  (i.) The prevention of motion.
  (ii.) The transmission of motion.

(2.) Resistance with friction (sliding contact)—
  (i.) Production of heat or electricity.
  (ii.) Production of vibrations.
  (iii.) Abrasion of surfaces.
  (iv.) Absorption of energy.

(1.) Statical Contact.

(i) The prevention of motion by means of frictional resistance is effected in a very large number of appliances used in everyday life. This is the case not only in the ingenious contrivances which mark the progress of the mechanical arts, and upon which we now depend in a variety of ways, but in the clothes we wear and the dwellings we inhabit.

It might seem that in the numberless applications of statical friction there were a variety of principles involved, which admitted of classifications, such, for instance, as used by Professor Willis, who made a distinction between butting and jamming or twisting friction. In reality the only conditions which have to be fulfilled are, that the surfaces in contact are sufficiently rough, and the normal reaction between them sufficiently great, so that the relations expressed in the equation—

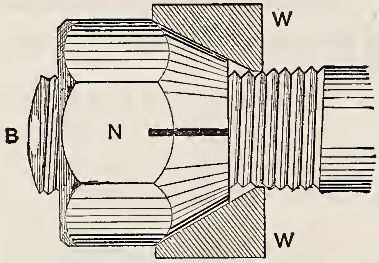
$$F = \mu R$$

shall be satisfied.

It is true that the normal reaction between the surfaces in contact may be obtained in a variety of ways. I shall not, however, attempt to make any arbitrary subdivisions, but proceed to consider such applications as are of novelty and importance.

The utility of nails and screws depends upon the frictional resistance which is due to the elastic nature of the materials, and without which no nail or screw would retain its hold. Where the screw is employed in contact with metal surfaces, as, for instance, in the case of a bolt and nut, the elastic reaction is frequently not sufficient to cause the hold to be retained when jarring action or vibrations occur. The vast quantity of bolts and nuts employed under such circumstances, where human life and property depend upon their retaining their relative positions, as, for instance, in the permanent way of a railroad, have led to a large number of ingenious devices for increasing the frictional resistance of the nut upon the bolt. It will be sufficient to explain one of these. Fig 42 represents the gripper lock nut, in which the nut, N, is turned to fit a conical recess in a washer, W W, (shewn in section). When the nut is screwed home upon the bolt, B, the saw cut in the nut allows the sides of the conical portion to close together upon the bolt, and grip it with a force depending upon the tension brought to bear upon it. In some devices a spring is interposed between the bottom of the nut and the surface against which it is screwed, so as to always cause a pressure against the sides of the screw thread, and thus obviate the injurious tendency of any jarring action, which is specially felt when the nut and bolt do not fit each other in a proper manner.

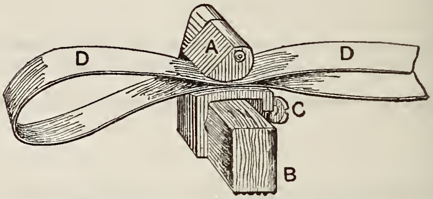
Fig 42.



Gripper Lock Nut.

In a large number of contrivances, the requisite normal reaction of the surfaces is brought to bear by the very tendency of the external forces to overcome the frictional resistance of those surfaces, the resistance increasing with the increase of the external force. An example of this kind is the invention known as the "Jockey" rein-holder. This ingenious contrivance (shown in Fig. 43) enables the reins, D D, to be held by the frictional resistance resulting from the pressure between the excentric block, A, and the frame. The action is easily understood, for it is only necessary to insert the reins sideways under the block, A, which is previously lifted. When the block falls it grips the upper surface of the rein in such a manner that, the harder the horse pulls, the more firmly the reins are held. The whole contrivance is fixed to the dashboard, B, by simply screwing up the set screw, C.

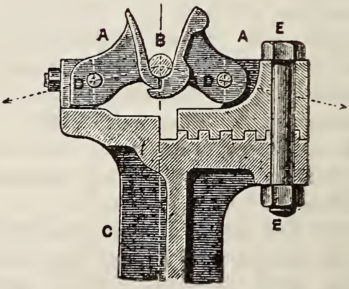
Fig. 43.



The "Jockey" Rein-holder.

Another device of this kind is the valuable clip drum of Fowler (Fig. 44), which is much used in towing and agricultural operations. In this appliance, of which a section through the rim of the drum is shown, the wire rope, B, is pressed between two clips, A A, pivotted at D D, the surfaces of which are excentric with the pivots. The greater the tension in the rope, the greater will be the downward force pressing

Fig. 44.



Fowler's Clip Drum.

it between the clips, and consequently the greater will be the frictional resistance which acts to prevent it from slipping.

There are a great number of contrivances in which "jamming" friction, as it is called, is employed; such is the case in tying of "knots" in rope. The only difference between the efficient "reef knot," which I now make, and the inefficient "granny" is, as you see, simply relative position of the coils, which in the former case "jam," and in the latter do not. A number of jamming friction contrivances were long ago described by Willis, in his "Principles of Mechanism." He there mentions and gives an illustration of the "scheme" of Dr. Hooke, proposed 200 years ago, to "stop great weights falling," and which was the forerunner of numerous "safety" appliances now in use. Time does not permit an account to be given of the modern devices of this kind, or of the many other contrivances, such as the "silent feed" for replacing ratchet wheels in which jamming friction is adopted.

One of the most important features in the use of statical friction must now be pointed out. In a large number of cases it is required to lock together surfaces which have initially a motion relatively to each other. A certain amount of energy of motion must be absorbed before this can take place, and the required uniform condition of rest or motion must be brought about gradually. By means of frictional contact, this can take place with the only injurious result of a certain amount of abrasion and heating of the surfaces. Thus there is a class of contrivances in which this important property is taken advantage of.

A simple and well-known application is in the case of coil friction. A rope which takes half a turn round a post will enable a force on one side to resist or sustain another force three times as great on the other. For every half turn the resisting power is multiplied three times. Thus a man pulling with a force of only 30 lbs. could, with five complete turns round a post, oppose a resistance of no less than 657 tons. But although this large force is available, it is clear that, by reducing the number of turns, or diminishing the pull, the resistance may be reduced to any required extent, and may be brought to bear as gradually as required. Thus it is clear why a large ship can be brought to rest by one man, or a luggage train set in motion by a small revolving steam or hydraulic capstan, without involving any sudden shocks.

Brakes act upon the foregoing principle, but these will be alluded to later on, and we must also pass over other contrivances, such as the injector, which really acts on this principle, and conclude the first subdivision of statical friction with the consideration of one kind of application of great importance, viz., friction clutches.

Friction clutches serve to connect revolving shafts either with other lengths of shafting, or with machines, and offer the great advantage of enabling the shaft or machine at rest to be connected with the revolving shaft without previously bringing the latter to rest, as must in many cases be done when clutch couplings or similar modes of connection are employed. Well known examples of this kind of appliance are the friction clutches of Brown, Addyman (American), and Stephenson.

It will be sufficient to show and explain illustrations of these and other clutches, but through the courtesy of Messrs. Mather and Platt, I am able to exhibit to you a model of their friction clutch, which is extremely simple, and at the same time, most efficient in its action.

Accounts of the foregoing clutches have appeared in various papers and journals, but I will now describe to you a friction clutch invented by my brother, Mr. Edward Shaw, of Bristol, of which a published description has not hitherto appeared, and which is in many respects a very beautiful invention. Fig. 45 (p. 1246) shows this clutch in sectional elevation, and Fig. 46 (p. 1246) in side elevation. The frame, B B, is attached, by means of a feather, to the shaft, and thus turns with it. The outside shell, C, carries the driving belt, and is free to revolve on the shaft. Between the bosses of B and C is a spiral spring whose action is to force them apart. The inside of the pulley C, is conical, the arms, B B (see Fig. 46), carry sliding surfaces, which before being turned up concentric with the shaft, are sprung out at the free ends by means of the nuts, K K, the pressure being transmitted from one side to the other by means of a cylindrical frame, M, with screwed parts carrying the nuts. After being turned, the nuts are screwed back, and thus the blocks, W W, which work on these faces must move outwards or inwards as they slide in one direction or the other, the small spiral springs tend to pull them in such a direction as to move them inwards. On the outer faces of W W are fixed oak blocks, which fit the inside face of C. When the clutch is not required, a lever forces B along the shaft towards C, thus separating the conical faces on C and W W. When the lever is released, the spring, S, separates B and

C, bringing the conical surfaces into contact, the frictional resistance between them causing a grip between W W and C, and thus the revolving frame, B B, moves on, leaving W W behind. Thus the pressure between the conical surfaces is increased to any desired amount. The action of the clutch may briefly be described thus: a small pressure along the shaft is sufficient to make the conical surfaces touch, directly they do so, the driving power causes the blocks, W W, to slide on B, so as to increase the grip. The resolved pressure between the conical surfaces is rather less than the angle of friction, hence there is little resistance to throwing the clutch out of gear.

(ii.) The transmission of motion by statical contact occurs in the case of rolling friction, but (as we have seen in Lecture I.) actual statical contact, even with the smallest forces, in reality never occurs. For practical purposes, however, we may usually neglect the amount slipping which occurs when the surfaces in contact are hard, and consider that they simply roll upon each other. When this is the case, although the points of each surface in actual contact have no relative motion, yet every other point in one surface is moving relatively to all points in the other.

Fig. 45.

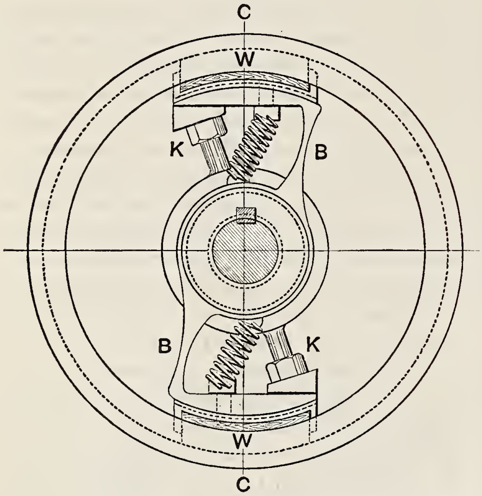
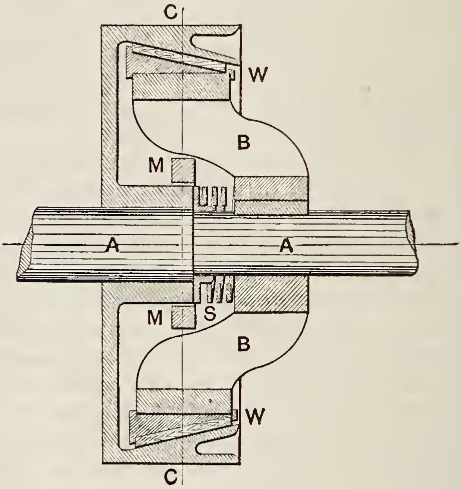


Fig. 46.



Friction Clutch, invented by Mr. Edward Shaw.

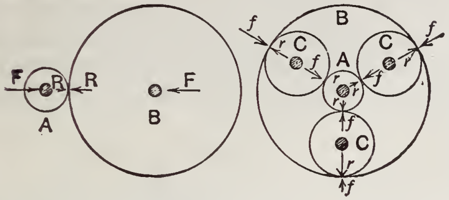
The primary object in the use of two rolling surfaces may be either the transmission of force, or the transmission of a definite motion, and we will consider these two applications in succession.

I have already mentioned the transmission of power by belt and rope gearing, which are examples of rolling friction; in these cases the contact occurs over an appreciable area, but in the large class of what is specially called "friction gearing," the contact occurs over a very much smaller area of surface.

Friction gearing has the great advantage, already pointed out, of obviating sudden and injurious shocks by a momentary slipping of the surfaces, and for this reason is largely and increasingly employed in cranes and hoists. It has also the advantage of being nearly noiseless in action, and has thus been adopted for driving dynamo-electric machines. The disadvantage which attends its use, but which, as I shall show, has been considerably exaggerated, is due to the fact that, in order to obtain the necessary normal reaction of the surfaces, the pressure on the bearings has to be correspondingly increased. Attempts have been made from time to time to obviate this objection. The late Professor Fleeming Jenkin invented what he termed "nest gearing" for this purpose, the principle of which will be made clear by means of the annexed figures (Figs. 47 and 48, p. 1247).

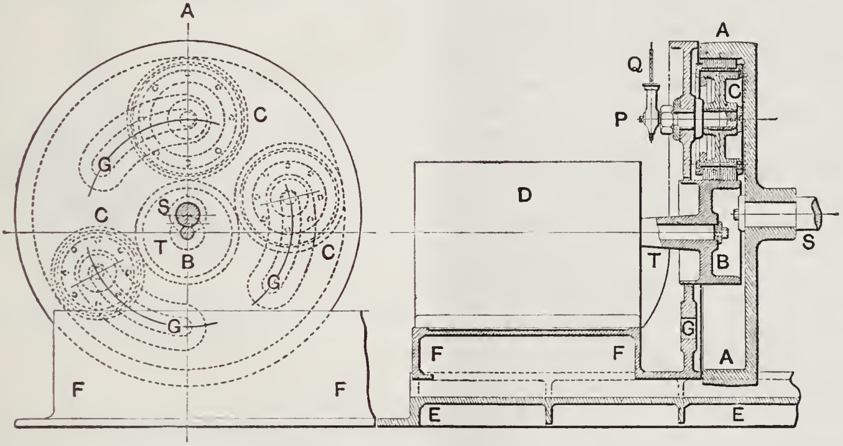
Fig. 47 shows that the reactions, R R, at the point of contact cause equal reactions on journals at F F, of the shafts A and B. Fig. 48 shows the principle of "nest gearing." Three idle wheels, C C C, are interposed between the inside of the driving wheel, B, and the driven wheel, A. It will be seen that not only is the necessary friction at the points of contact (and consequently the normal reactions *r*, *r*, *r*) reduced to one-third of the former amount, but, what is more important still, the three reactions balance each other, and consequently there is no journal pressure at all. This idea was not, however, new, and Professor Jenkin mentions in his paper on the subject before the British Association,* that Mr. Foster had, in 1882, patented one form of nest gearing, and Mr. Tibbits, another one earlier still. The idea is, I have found, much older than any of these inventors seemed to have been aware, for, in 1842, Mr. Elijah Galloway proposed an arrangement somewhat similar to one form described by Professor Jenkin in his paper as having been applied to a telpherage locomotive. Galloway's contrivance was designed for the purpose of driving a screw-propeller shaft, in the days when high-speed engines were not considered possible, and intermediate gearing was always used between the engine and the screw shaft. He proposed to fix a double coned cast-iron drum upon the engine shaft, the cones being formed upon the inner edges of the flanges of the drum. Between these flanges were placed two much smaller cones, one being keyed to the screw-shaft, and the other to an idle shaft. The idle shaft was pushed towards the drum by a spring, and so the cones were always kept in contact with each other and with the drum. The drum, upon being turned, actuated the cones, and thus gave motion to the screw-shaft by frictional contact, the necessary normal pressure for which was obtained without causing any pressure upon the bearings of the shaft.

Fig. 47. Fig. 48.



Rolling Friction and Journal Pressure.

Fig. 49. Fig. 50.



Friction Gearing with Eccentric Adjustment.

It is clear that, with the arrangement shown in Fig. 48, some device is necessary to keep all the wheels in frictional contact, and the idea that Professor Jenkin had for doing this was to place the centre wheel (A) eccentrically to the driving-wheel (B), and to have one of the idle wheels (C) smaller than the two others, the necessary tightening being effected by forcing one of the larger idle wheels into the narrower portion of the space between A and B. This had been previously suggested, he afterwards found, by Mechwart, though not for friction gearing. A large winch was made on this principle, which was not altogether well designed; and although it was said to have an efficiency of 80 per cent., it did not, so far as could be seen, do justice to the nest gearing of Professor Jenkin. Perhaps it was, from this cause that he was led to express an opinion that the eccentric method of tightening would prove less convenient than certain other plans. As far, however, as I am aware the eccentric method is the only one now in successful operation, and is employed in the combined Armington-Sims engine and dynamo. Figs. 49 and 50 (for which I am indebted to the courtesy of Messrs. Greenwood and Batley) give views respectively in side and front sectional elevation.

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* Report of British Association, 1883, p. 387.

From these views it is seen that the engine shaft, S, has attached to it the large wheel, A, upon the inner surface of which roll the three idle wheels, C C C, all of different sizes, which are driven by frictional contact, and in turn drive the wheel, B, which is attached to the spindle, T, of the dynamo, D—carried upon the framing, F F.

The adjustment is effected by three curved slots G, G, G, in ribbed plate supported on the frame. Fig. 50 shows how the spindles, D, of the idle wheels are constructed and fixed, and also the ingenious device by which a constant supply of lubricant is ensured, the spindle, Q, being attached to a heavy weight which rests upon the lubricating material, and forces it along the hollow spindle to the bearing in the boss of the wheel, C.

Although the advantages of nest gearing are undeniable, there are certain objections which are likely to be overlooked, the chief of these being that there *is* such a thing as rolling friction. Thus, by comparing Figs 47 and 48, it is evident that the number of points of contact, and consequently of points of rolling friction, is six times as great in the case of nest gearing. This does not, since the pressures are much reduced, involve a corresponding increase in rolling friction, but still there is a decided increase. Secondly, the frictional resistance of the bearings under heavy pressures is much exaggerated, and arises, as we have seen, from a misapplication of Coulomb's laws; in a properly constructed and lubricated bearing the friction does not increase directly with the pressure, or in anything like that proportion. Thus, considering the extra complication entailed with nest gearing, there are evident reasons why it has not yet been very widely adopted.

We now come to an important advantage which the method of transmitting motion by the frictional contact of surfaces has over any other. This advantage is the possibility of varying in any way the relative speeds of rotation of the driving and the driven bodies. In the case of belts, this is done by employing a pair of conical frustra, the larger ends of which are turned in opposite directions. The frustra are keyed upon two parallel shafts, and by causing the belt to move along them, the relative speeds or velocity ratio can obviously be varied in any required manner. In the well-known disk and roller, the roller is caused to slide sideways across the disk, which drives it by frictional contact, and thus velocity of rotation is varied relatively to the disk. In both these cases, however, the surfaces in frictional contact are made to slide over each other, and this it requires considerable force to effect, and causes no little wear of the surfaces. About two years ago, I was led to attempt to solve the problem of varying the velocity ratio without introducing any sliding action at all. The solution at which I arrived is fully described elsewhere,* and I will only briefly describe the general principle of action. Figs. 51 and 52 represent the plan and elevation of a sphere supported by two sets of rollers. One of these sets, A A′, B B′, is in frictional contact round the horizontal great circle or equator. The other, C C′, D D′, is in contact round a circle made by the intersection of some vertical plane. The latter set are carried in a movable frame, F F, which can turn about a pivot, E E. The former set are carried in a fixed frame, I, I. Suppose the wheel or roller, A, be turned, then the sphere must also turn; but as it can only roll about an axis in the plane of the axis of A (*i.e.*, in the horizontal plane), and as it also can only roll in the plane of the axes of C C′, D D′, it is clear there is only one axis

Fig. 51.

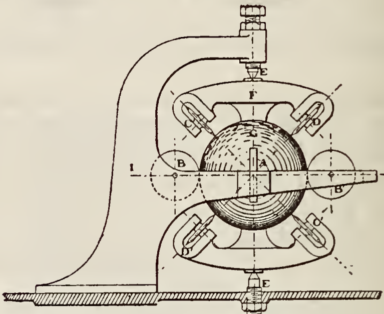
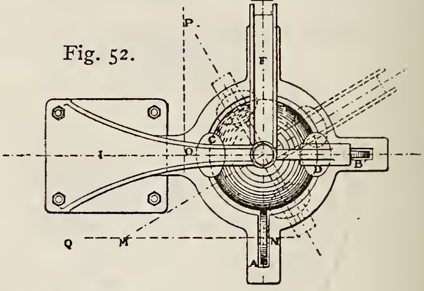


Fig. 52.



Variable Velocity Ratio by Friction of Sphere and Rollers.

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* "Phil. Trans. Royal Society," Part ii., 1885, p. 367.

about which it can roll, viz., the intersection of these two planes. Thus, by turning the movable frame, the axis of rotation can be made to take any position, and the relative velocity of the roller A to that of the roller B can be varied in any required manner by an action which involves merely the rolling of the wheels upon the surface of the sphere, *without any sliding friction*. My brother, Mr. Edward Shaw, has since developed and applied this mechanism for transmitting as much as 2 h.p., and, although the practical difficulties were very considerable, they have, to a great extent, been successfully overcome.

So far we have merely considered the transmission of appreciable forces, but there are a class of instruments in which the forces are not appreciable, the only object in view being to transmit a definite motion. Friction is sometimes used to transmit simple rolling, but it is for variable velocity ratios that the application is specially valuable. An example of the former class is the odometer, which appears to be a very ancient instrument, having been mentioned by Vitruvius as applied to carriages. This instrument merely consists of a wheel which is rolled along a curve or line whose length is required, The periphery of the wheel being known, and the number of revolutions of the wheel recorded by a suitable train of wheels, the calculation is easily made, or, as is more usually the case, the result is at once recorded upon a dial.

The most important instruments in which the velocity ratio or relative speed of the rolling surfaces is varied, are called "mechanical integrators." These instruments multiply together two variable quantities, such as the length and breadth of an irregular figure, or the pressure of steam and corresponding distance moved by the piston in a steam-engine, and perform operations which would be scarcely possible if the frictional contact of two surfaces rolling upon each other were not employed. All mechanical integrators may be divided into two classes, in which either—

I. *Both* slipping and rolling of the surfaces take place;

II. The correct action depends upon the surfaces rolling *without* slipping each other.

I. The former class has only been successfully employed where the motion is not continuous, and not very rapid. This is the case in the use of "planimeters," by which the area of a figure drawn upon paper can be obtained by merely passing round the perimeter a pointer, connected in a suitable manner with one or more wheels, rolling over the surface. The only planimeter which can be said to have come into general practice is that of Professor Amsler, invented in 1856. Other instruments of this kind had previously been suggested, as, for instance, in 1814 by Hermann, of Munich; by Oppikofer, of Berne, in 1827; and by Gonella, of Florence, in 1828. The planimeter of Oppikofer obtained a prize at Paris, in 1836; but Wettli, of Zurich, in 1849, seems to have been the first to produce an instrument of practical importance. The planimeter of Amsler is, however, so beautifully simple, and so marvellously exact in its operation, that it is little to be wondered at that it has practically superseded all others, since its invention no less than 12,400 having been made and sent out from the works at Schaffhausen. All the previous planimeters had been "linear," that is, the motion which must be possible in every direction over the surface, was obtained by compounding two motions at right angles to each other, whereas that of Amsler was "polar," the motion being obtained by two arms, one turning about a fixed centre, and the other jointed to it.

Planimeters have a variety of forms, and have been the subject of many inventions, but it is a curious fact that in all planimeters of the class we are now considering, that is, in which both sliding and rolling take place, the principle of action is the same. I have elsewhere proved this point, and given an account of different kinds of planimeters.*

It is clear that any relations of the nature of a product between two varying quantities may be represented by a drawing. This is so, not merely in the case of the superficial contents of an area, such as a field or tract of land, but also in a case such as that of an indicator diagram representing the work done in the cylinder of a steam-engine or other prime mover. It is in many cases much more convenient to obtain the required product directly, without previously making a diagram or drawing, and to do this several integrators have been invented, in which the roller or measuring wheel slides as well as rolls, such as the integrators of Poncelet, Moseley, Ashton and Storey, and others. Since, however, the accuracy of the instrument depends upon the rim of the roller being a circle of an exact size, and since some appreciable pressure is necessary to obtain sufficient frictional contact, the unavoidable wearing of surfaces in contact which takes place, has hitherto proved one insuperable objection to their permanent employment. Other integrators of the slipping class might be considered did time permit, such as the beautiful "precision planimeters" of Coradi and Hohmann, and the "Moment" integrators of Amsler; but we must pass on to those of the purely rolling class.

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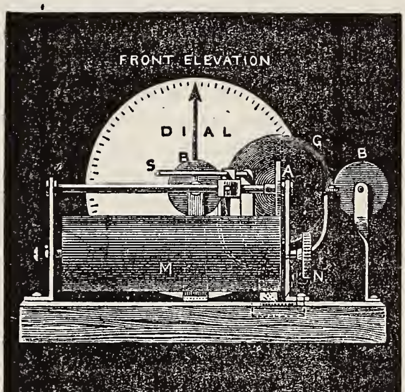
* "Mechanical Integrators," Minutes of Proceedings of Inst. Civil Engineers, Vol. lxxxii. p. 75, to which paper the reader is referred for further information on the subject.

Fig 53.



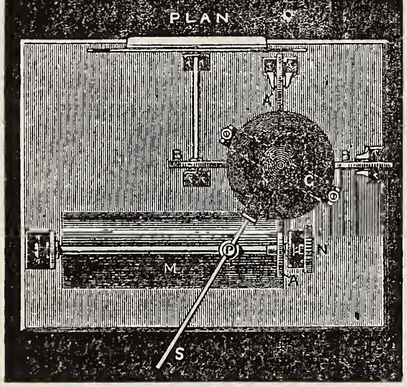


Fig 54.
SPHERE AND ROLLER INTEGRATOR.

(II.) Integrators in which there is no slipping have not been introduced to any extent for merely finding the area of a surface, that is as planimeters. They have even for this purpose certain advantages over those of the previous class which do slip, but these are not sufficiently marked to counterbalance the fact that they are not so simple in construction, and consequently cost more. Examples of these are the integrators of Abdank-Abakanowicz and Mr. C. V. Boys.

It was in the endeavour to invent a non-slipping integrator that I devised the sphere and roller mechanism which I have previously explained. Fig 53 shows in elevation, and Fig 54 in plan, the first model of an integrator made on this principle, which can be more easily explained than some of the later forms of instruments. A sphere of boxwood, G, is held in a frame simply formed by bending round suitably shaped sheet brass, which thus caused the rollers to grip the sphere. The rollers, A A, B B, were discs of boxwood, and merely had common red elastic bands cemented upon their peripheries. The paper on which is the area to be integrated is folded round a cylinder M, and held there by two indiarubber bands. The cylinder is turned by means of a milled wheel, N, with one hand, and the pointer P, which is connected with the movable frame of centres, is kept on the curve with the other. The roller, A, works in contact with the surface of the paper, and communicates its motion by frictional contact of the indiarubber to the sphere. The motion of the pointer connected with the axis of B is registered on a suitable dial. The reading of the dial gives the required area of the figures.

Though the results with the early forms of the sphere and roller integrator were as accurate as could be expected, yet there was always a certain mysterious error in these instruments, even when made by the very ablest mechanicians, the cause of which I could not discover for a long time, but which I have at last traced to a certain property of surfaces which roll upon each other, and are at the same time subjected to a force not in the plane of rotation. I will not now, however, say more upon this point.

Although not much employed as planimeters, integrators of this class have advantages which those of the slipping class cannot possibly possess. One of these advantages is the possibility of their being employed to trace curves representing the result of integration. Instruments which do this are called "integraphs," and both Mr. Boys and Mr. Abdank-Abakanowicz have devised instruments of this kind.* Fig. 55 (p. 1251) represents the latest form of integraph devised by the latter gentleman. The iron straight edge at the lower end of the figure serves as a guide upon which run certain rollers in the movable frame of the instrument. This frame carries a pointer, A, which is passed round the curve the area of which is required. Another pointer, B, between two other rollers at the same time traces the integral curve (a portion of which is shown, though not very clearly, on the shaded portion of the sheet of paper. The area of the first curve is measured by the height to which pointer B rises in drawing the second curve.* Another advantage possessed by this class of integrators is that they can be employed where continuous motion is required, as for instance, in steam-engine integrators, for since the measuring wheel only rolls and does not slide, it is not liable to lose its initial form. In spite of this obvious advantage of non-slipping integrators, they have not yet been successfully introduced for such purposes, though it would not perhaps be a rash thing to predict an important future for them in this direction.

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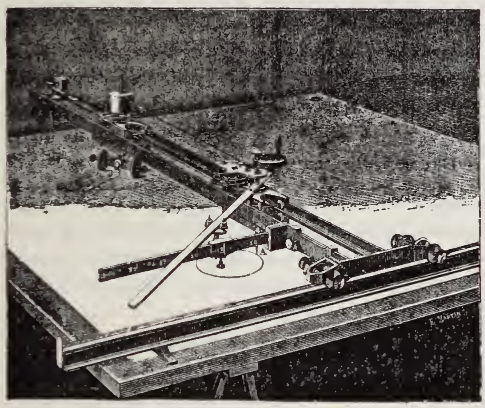
* Integraphs trace the curve $y = \int f(x)\,dx + c$ from any iven curve of the form $y = \phi(x)$.

Fig. 55.



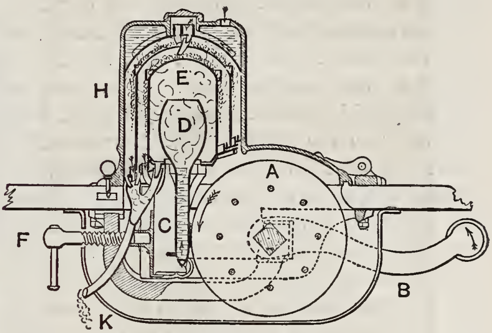
Integraph for tracing Integral Curves.

(2.) Sliding Contact.

(i.) The production of heat for the purpose of obtaining fire was probably one of the earliest mechanical applications of friction, and it has been conjectured that the fire-drill for doing this was the earliest case of machinal motion. At the present day every lucifer match testifies to the fact that we are dependent for fire upon the same source. The conversion of mechanical energy into molecular motion is not, however, a very profitable mode of obtaining heat upon any large scale, since 1 lb of water can only be raised 1° in temperature by the expenditure of energy sufficient to raise 772 lbs. one foot high, so that to boil a pint (initially at the average temperature of 62° Fahr.) would require an amount of work capable of raising no less than 144,000 lbs. to the same height; and heat when produced by friction generally takes place as a loss of energy which, as we shall see in the next lecture, has specially to be guarded against. A recent invention which employs the conversion of work into heat has, however, been made which is of considerable interest, and must be mentioned.

The "friction still" of Mr. Lionel Pearce is an invention for converting sea water into fresh, by means of a machine so simply constructed, that to pour in sea water and to turn a handle are all that are necessary in order to obtain a supply of pure drinkable water. The invention was recently described in *The Engineer* somewhat as follows:—

Fig. 56.



Friction Still.

Fig. 56 shows a friction still, fixed to and let through the seat or after thwart of a ship's boat; above that seat is the condensing or domed part, and below is the malleable iron framing. The machine may, of course, be fixed to the most convenient place in a boat. The framing may be said to consist of two parts, one fixed and the other movable, the fixed frame being bolted through the seat, fixes the part above the seat to that below. The metal supporting the boiler must be understood to be part of this fixed frame, though the section does not clearly show it. The movable frame is capable of a sliding motion in three bearings, one above the pressure screw, F, and another to each side of friction wheel, A. It is single where shown in section, and branches off to each side of the wheel to form bearings for the spindle. This frame brings the friction wheel, A, in contact with the boiler, C, with any desired pressure, regulated by the pressure screw, F. The inequalities which may occur in the periphery of the friction wheel are compensated for in the elasticity of the packing. Either side of the spindle may be fitted with a handle, B, and the same still can be worked effectively within the range of power from that of a lad of fourteen years of age to 4-man power. The boiler, C, is held in a hard wood block, to prevent heat being readily conducted to the metal frame supporting it. The upper part of the machine is hinged, and may be thrown open, leaving boiler and friction wheel exposed; the inner domes also hinge open or take out for any attention that might be required. The overflow tank is pivotted so as to be easily released from the boiler. The manner in which it is fed and the action is as follows:—It will be seen that the upper tank, H, is full of sea water. From this tank the water is made to pass at intervals down small pipes shown in the centre, and feeds or saturates the flannel with which the two domes are covered. The sea water, after it has left the coverings, as it is collected by its trough, runs through a pipe into the overflow tank, which tank is connected with boilers in keeping that fed with sea water to the height allowed by overflow tank; the overflow from the middle dome is allowed to run away as cooling water, because that from the inner dome is sufficient feed for the boiler, and being hotter than that from the other dome is preferred. The water enters the boiler at the bottom, as shown by the arrow. The heat result of the friction of the wooden wheel, A, against the steel on the boiler, causes the sea water to boil in about half a minute. The steam then rising is trapped in the dome, E, and condensing upon its inner surface, drains away into its trough, then from that to outlet pipe, K. The condensed steam or distilled water may be traced throughout the engraving indicated as drops. The heat given up by the steam condensed upon the inner surface, E, will be imparted to the sea water held in the saturated flannel covering the dome; this water is freely vaporised at a lower temperature than that required for the boiler, its vapour being condensed upon the inner surface of dome enclosing it. The action of vaporising and condensing goes on in the next compartment, as just described, but at a lower temperature; the product from the three condensing surfaces can be traced as drops all flowing into and out of outlet pipe, K. The feed water in the tank will, when the machine is in full work, reach a temperature that a delicate hand cannot bear by heat imparted to it from the vapour which condenses upon the domed bottom of the tank.

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* This instrument is fully described in the "Comptes rendus de l'Academie des Sciences," vol. ci., 1885, p. 592.

It was known to the ancients that on rubbing amber, light bodies in the vicinity were attracted to it. This effect was ascribed by Thales of Miletus to an inherent soul or essence, which being aroused by friction, went forth and brought back these substances to the excited amber. We do not know much more at present about the nature of electricity, although we do not quite believe that the attraction is due to this cause. We have, however, gone far beyond rubbing pieces of amber by hand, and there have been a variety of machines invented during the last 150 years, culminating in the large Wimshurst machine for the production of electricity on a large scale by friction. We are not certain that the so-called current electricity produced by the dynamo electric machine is not produced by some action of the nature of friction, or whether friction is not the cause of the resistance in a wire to the passage of an electric current, which resistance results in the production of heat, just as obtained by the expenditure of mechanical energy in friction. But I am afraid others far more competent to discuss this question than I, are yet unable to throw much light upon it.

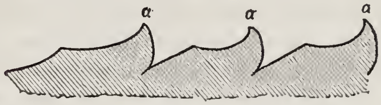
(ii.) Concerning the production of sound by friction, I need only point out that to this effect we owe the action of most of our stringed and wind musical instruments. In wind instruments, such as organs, the friction of the air in passing over the edge of the orifice in the pipes sets the column of air in vibration, and so produces a musical note. In stringed instruments, such as the violin, the bow being drawn across the string, draws it to one side, its elasticity bringing it back, and thus setting up musical vibrations, rosin being applied to increase the frictional resistance. Other sounds are produced in this manner by friction, which, though useful, are not always musical, such as those of the fog horn and steam siren, and it must be remembered that all sound is more or less modified by the friction of the air, without which the aërial waves could scarcely either be generated or dissipated.

(iii.) The grinding and polishing of surfaces by means of friction, as performed by the forces of nature, is a well-known effect. Buildings and monuments which have resisted all other forces have been defaced and changed in appearance by sand carried by the wind, and it is well-known that the windows of houses exposed to the action of wind carrying sand become dull from this cause. I cannot attempt even to enumerate all the applications of this kind in the mechanical arts. To produce effects upon the hardest bodies friction has been employed from the earliest times, and is still used with the most astonishing results, by some savage tribes. Thus, Mr. Wallace, in his "Travels in America and Rio Negro," tells of holes four to eight inches bored through hard quartz ornaments by the agency of the friction of sand with water, applied by means of a flexible leaf-shoot, one hole being probably the work of years, and, in some cases, possibly of generations.

Mechanical science has found a way to expedite the process of cutting hard materials by frictional effects, and I will allude to one such process, which is the application of the sand-blast by Mr. Tilghman, for an account of whose work I am indebted to the columns of *The Engineer*. Mr. Tilghman has applied the capability of fast moving sand to cut the hardest materials. The process was matured by him, and first used to cut stone for building and other purposes, the sand being impelled by steam at a pressure varying from 60 lbs. to 325 lbs. per square inch. The process consists in projecting sand at a great velocity by a jet or jets of air or steam against any hard surface, by which means the hard substance is slowly or rapidly worn away according to the velocity of the current or blast of sand. With quartz-sand, driven with high-pressure steam, granite crumbles away like a pile of sand under a falling stream of water, and even corundum can be drilled or grooved with ease. Diamond, the hardest of all substances, cannot withstand its action. With the steam-blast, cast-iron stencils, $\frac{1}{4}$in. to $\frac{1}{2}$in. in thickness, are used to protect the surface which is not required to be cut away. The blast is then directed at right angles to the surface, and moved by suitable mechanism regularly over the whole surface. With a jet using 6-horse power of steam, at 60 lbs. to 70 lbs. pressure per square inch, and $1\frac{1}{2}$ cubic feet of sand per hour, $1\frac{1}{2}$ to 10 cubic inches, according to the hardness of the stone, may be cut away per minute.

This process has many interesting applications, such as the ornamenting (by frosting) of glass, the cleaning of castings, ornamenting buttons, and marking glue, but one of considerable importance must be described. Files, when newly cut, have a burr or ridge, as at *a a a*, Fig. 57. This burr is a considerable evil, as it causes the teeth to be broken at the points when used. To propose to sharpen the file by the abrading action of a sand blast would appear altogether unreasonable; yet an effect is actually produced which make the points of the teeth take a shape somewhat as shewn at 3 3 3, Fig. 58.

Fig. 57



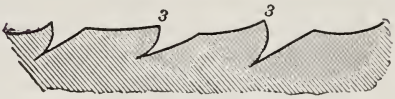
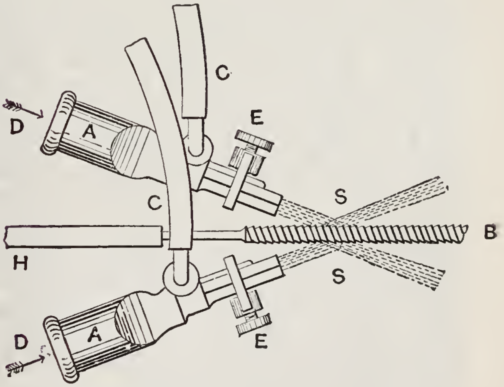


Fig. 58

Teeth on File before and after the Sand Blast.

The two jets of steam are blown in the direction of the arrows, D D, Fig. 59. A mixture of sand and water comes along the pipes, C C, and is met and carried by the steam upon the file, B, in the manner shown at S S; the jets are regulated by the screws, E E. A rest (not shown) serves the double purpose of holding the file in position, and enabling the operator to tell, by moving the file to and fro upon it, when the teeth have reached a good cutting edge. The kind of sand used is exceedingly fine, and is the waste material obtained in the process of grinding plate glass. The Tilghman Company have recently made further improvement in the sand blast process.

Fig. 59.



Sharpening Files by Friction of Sand.

In practice, the most simple and inexpensive way of giving the necessary velocity to the sand has been by steam. Notwithstanding these advantages, the difficulty of manipulating the articles to be frosted, engraved, perforated, &c., in a chamber full of steam or vapour, the difficulty of finding a suitable resisting material which will not be affected by either heat or moisture, the danger of breaking in the case of glass by the heat of the steam, the danger of the stencil getting clogged with sand, has precluded its use in many manufactures. In consequence of these objections, an air blast was used instead of steam. In the new arrangement, steam is used to give velocity to the sand, which passes along after being freed from steam and cooled. This new sand blast has, therefore, the advantage of the steam blast without its objections. The force of the blast can be easily regulated, from the low blast required to engrave table glass to the strong blast required to perforate sheet glass.

(iv.) The last application which we must consider is the absorption of energy, and this alone might form the subject of a lecture. The use of brakes makes ordinary conveyances safe and railway travelling possible. In the revolving fly of striking clocks and musical boxes we have an application of frictional resistance for regulating speeds which finds its development in some of the most beautiful devices of governors for marine engines, such as those of Silver, Huntoon, Thomson, Siemens and others, while the principle of the cataract of the old Cornish engine, which regulates speed by varying the size of an orifice through which liquid is made to flow, has been applied in the well-known service buffer, and has its latest application in regulating the number of shots fired in a given time by the Maxim gun. Again, the use of friction is employed to absorb the energy, and thereby measure the power, of prime movers in machines, as in the dynamometers of Prony, Armstrong, Egen, Cadiat, and others, where the friction of solid surfaces is used, and in that of Froude, where liquid friction is employed.

The above are a few cases in which the friction of solids, liquids, and gases are employed to absorb energy for useful purposes, and these examples must suffice.

I have endeavoured, in the brief space of a lecture, to give some account of the useful applications of friction, but it is not by these applications that the important part it plays in the economy of the world is most strikingly seen. It is, indeed, scarcely possible to picture the results that would follow the cessation of the action of friction. The whole face of nature would be at once changed, rivers and winds would flow with incredible velocity, though their effect would be very different from what it is at present; the latter, for instance, would raise no ocean waves, and no tides would flow up estuaries and channels; much of the dry land, and, even more rapidly, most of our buildings, would disappear beneath the sea. Such inhabitants as remained for a short time alive would not only be unable to provide themselves with fire or warmth, but would find their very clothes falling back to the original fibre from which they were made, and if not destoyed in one of the many possible ways, such as by falling meteors, no longer dissipated by friction through the air, or by falling masses of water, no longer retarded by the atmosphere and descending as rain, would be unable to obtain food from inability to move themselves by an ordinary method of locomotion, or, what would be equally serious, having once started into motion, from being unable to stop except when they came into collision with other unhappy beings or moving bodies. Before long they, with all heavier substances, would disappear for ever beneath the waters which would now cover the face of a lifeless world.

ADDITIONAL LECTURES.

JAPANESE ART WORK.

By Ernest Hart.

Lecture III.—Delivered May 18, 1886.

Part I.

In Japanese art, the painting is that which offers perhaps the highest degree of beauty, and at the same time, needs the greatest indulgence; and before entering on any study of the schools of Japanese painting, it would be well to premise some preliminary considerations. Japanese critics have always insisted that painting is a manifestation of the sentiment which the observation of nature inspires in man, and the older critics insisted that a picture is but the reflection of the image impressed upon the heart of the artist. They use the word "heart" when we should use the word "brain." It was, with them, another form of poetry, with this difference—the poet describes the sentiment, and the painter draws the subject of his inspiration. When the painter could communicate, by his image, to others, "the sensation imprinted on his heart," then he had attained his object. The earlier artists made many experiments. They were of opinion that merely to copy what the eye saw was insufficient, and they endeavoured to reflect the soul of nature, even more than the outline. They esteemed drawings in black and white, which they called light and shadow, much more highly than we do; and it is one result of their theories that no class of work was more highly esteemed than purely impressionist and rapid, cursive, and caligraphic drawings in Chinese ink. Their most impressionist painters, however, did not think that they could arrive at reflecting the soul of nature without first carefully studying the form, and they passed their early life in training themselves to minute copies of external forms. In their later life they arrived at that point which, in their theory, enabled the artist who had already achieved technical skill to express the impression on his mind, or what he would call the soul of natural objects, by drawing them without a model, and as long habit of observation and memory had impressed their essence and sentiment upon his mind. Thus nothing was more naturalistic and minute than the earlier work of men such as Tanyu and Korin; nothing more ideally impressionist than their later work. But this impressionism is not an attempt at copying the thing itself, but at reproducing concentrated inspiration which years of study has imprinted on the mind. Indeed, you will find that, judged without direct reference to Greek or European canons of art, these rapid drawings in ink, these shadowy and almost shapeless outlines or blots of colour, differ wholly from the photographic school of art not only in being technically almost shapeless, but in that, even in their vagueness, and perhaps you will say in the deformity of some of them, they speak to the educated eye in language which you recognise as that of true sentiment, and they have an enduring fascination for the student who is capable of resisting coarser impulses, and of rejecting art products which have a standard which is not that of our own schools. To the Japanese the impressionist school which I shall have to introduce to you, represented by Kanaoka, Takuma, Chodensu, Shiubun Sesshiu, Kano, and especially by Koyetsu, Korin, and Tanyu, was essentially an intellectual school; while the naturalistic school which started with the Chinese school of Ming, and the Japanese school of Maruyama Okio and his followers of the Shijo academy, was recognised as a physical school of art.

The first artist recorded in Japanese annals is a Chinese Nanriu in the middle of the 5th century. Of his works, and those of his immediate successors, there are no known examples. It was in the 6th century that we have the first district evidence of the establishment of a school of Japanese art, which was then mainly dedicated to the mural decoration of the temples raised in honour of Buddha, whose religion was introduced into Japan at about this time. A wall picture in the temple of Horiuji, at Nara, said to date from 607, is still in existence, and a tracing of it has been presented to the British Museum by Mr. Satow. This Buddhist art, which was introduced into Japan by the Chinese and the Coreans, drew its first inspirations from India and China direct, and through the Corea; and inasmuch as Indian art was influenced by Greek examples, it is not surprising that we can trace a certain Greek influence in the earliest Japanese works of painting as well as of sculpture, and the comparison of the works of the early Japanese painters with those of the earliest Italian painters who worked under Byzantine influence, will readily suggest a common inspiration in the work of both schools with that of the great fountains of Greek art. You will notice this Greek influence not only in the great pictorial work of Kanaoka, which hangs behind me, but also in this grandly sculptured statue of Buddha of the 9th-10th century, to which I have already called your attention, and which is Greek in its draperies and diapers, and its grace and dignity. The history of Japanese painting from the 6th to the 9th centuries is more or less clouded with doubt. Various names are mentioned in the early books, and stories are told of the skill in portraiture of the artists of the Chinese and Corean schools who chiefly practised them. The arts generally, as you have already gathered from the sketch which I have been able to give you of the progress of sculpture, of metal work, of wood carving, of lacquer and, I may add, of architecture, reached a high degree of development in the interval between the 6th and the 7th century, and the sciences had made corresponding progress. Music, medicine, mathematics, philosophy, and astronomy all flourished in the 7th century in Japan, and the Buddhist scriptures were printed in the middle of the 8th century. Two of the greatest poets of Japan, whose portraits you will find frequently repeated in the bronzes, lacquer work, and picture books of my collection, were already numbered with the worthies of the past. Hitomaro died 724; Nakamaro, 716;

Narihira, 880; and Ono-no Komachi was still living in the 9th century. You see their portraits in this picture by Ritsuo. In this 9th century the Mikados, with their court, were devoting themselves to the spread and study of Buddhism as a religious system, to the extension and the decoration of its temples, and to art and letters, leaving the cares of government and the strife of battle to the military governors, the shoguns, and their subject nobles, the daimios and princes. Thus it is not surprising that in the first great Japanese artist with whose works we are authentically acquainted in the 9th century, we find pictorial art already far advanced, and, indeed, attaining, in the works of Kanaoka, a degree of perfection which has not been surpassed, or even equalled, by any of the later artists of the Buddhist school. The very few pictures which remain known to us as the authentic works of Kanaoka are entirely Buddhistic portraitures of deities, and although there are extant traditions deeply implanted in Japanese literature of his surpassing skill in the portraiture of animals, and as a landscape painter, there are no existing examples.

The picture, unique in shape, which I am able by rare good fortune to show you by Kanaoka is from the collection of Mr. Wakai. It has survived the destructive influences of time, and still shows qualities of colour and design, which I do not need to eulogise.

As to the artistic merits of the venerable master, the oldest and greatest of his school of whom we have any example, I prefer to quote the opinions of Paul Mantz, one of the most eminent of French art critics. He says of his pictures, that they are still superb in their warm harmony, which is dominated by rich browns, soft red, and sober tones of gold. The modelling is simple, large, and even subtle; the colouring is advisably toned slightly with yellow, which recalls to our mind a clear bronze of tranquil beauty, which proves to us that we are here in presence of a form of art which has attained to almost complete maturity. The robust school of colour—recognisable from afar in the predominance of the brown note appears characteristic of the early school of Japanese paintings. Passing from Kanaoka through the paintings of the Takuma school, which are here before you—the Meitshio in the 17th century—you will see that the traditions and the principles which Meitshio applies are the same that prevailed in the school of Kanaoka. It is a serious art, and Meitshio is the contemporary and homologue of the followers of Giotto. It is curious that, after having learned to admire the 15th century work of Italy and of Flanders, we have now to learn to love the work of the same period in Japan. Masaccio and Van Eyck, Van der Weyden and Ghirlandaio, had contemporary brethen in the far East—brothers in art whose existence they did not suspect. The example which I possess in my own collection, and which is attributed to Kanaoka, has suffered more.

Among the stories of Kanaoka's skill, which are most popular, is one which relates that the peasants of the province of Omis much disturbed at night by the nocturnal ravages of some creature which trod down their gardens, destroyed their flowers, and ate the herbs, laid wait for him one night, giving chase to the intruder who proved to be a wild horse. They chased him till he disappeared into the temple. Entering the temple he had disappeared, but as they stood wondering in the hall, drops of moisture fell upon their heads, and looking up they found that they were falling from one of the horses in a picture by Kanaoka; so lifelike was he that he had escaped from the canvas and had only just resumed his place, and was still sweating. This belongs to a type of story which is familiar in Chinese traditions, and Kanaoka is not the only artist to whose genius this childlike supernaturalism pays a like tribute. The evidence of our own eyes suffices to show that the genius of Kanaoka justified something like hero worship. From his time painting was not only the pursuit of academies and schools of artists of the Buddhist and lay type, but the favourite and highly esteemed accomplishment of nobles and of princes. One of the most celebrated artists of the immediately succeeding generations, Tadahira, is said to have painted a cuckoo upon a fan which uttered its characteristic note whenever the fan was opened, and Tsunenori to have drawn a lion so life-like that other beasts fled from it (Anderson). In the collection of stories and sketches in a famous romance of the 10th century, there is an account of a competition of painting before the Emperor, carried out with much ceremony, and in which the pictures shown are described in the following words:—

"Look for another instance at the eminence which has been attained by several of the artists of the Imperial College of Painting. Take the case of draughtsmen in black ink pictures indeed, such as those of Mount Herai (P'êng-lai) which has never been beheld by mortal eye, or of some raging monstrous fish in a rough sea, or of a wild animal of some far off country, or of the imaginary face of a demon, which are often drawn with such striking vividness that people are startled at the sight of them. These pictures, however, are neither real nor true. On the other hand, ordinary scenery of familiar mountains or calm streams of water, and of dwellings just before our eyes, may be sketched with an irregularity so charming, and with such excellent skill, as almost to rival nature. In pictures such as these the prospect of gentle mountain slopes and sequestered nooks surrounded by leafy trees are drawn with such admirable fidelity to nature that they carry the spectator in imagination to something beyond them. These are the pictures in which is mostly evinced the spirit and effectiveness of the superior hand of a master, and in these an inferior artist would only show dulness and inefficiency."

In the books there are long lists of Buddhist masters of the 10th century down to the 14th century, but of their work, or rather of what is known of them, I cannot further speak to you to-night in this short available hour. The greatest name next to that of Kanaoka in the history of Buddhist painting in Japan, is that of Meicho, in the latter part of the 14th century, better known as Cho-Densu (Cho, the priest.) In life, therefore, as in date, and in the style of his work, Cho-Densu, of whose brush I show you a fine work, may be compared with his contemporary priest, Fra Angelico. (Cat., Kakemonos, No. 4.) I need not say that such examples are excessively rare. Meichô is represented by fine examples in the Anderson collection at the British Museum.

He lived a simple and devout life, and his genius can, it is said, be only rightly estimated by a study of the great series of pictures by him, still extant, of the 500 disciples of Buddha, in the Temple of Kioto. "Here the artist's strength has had full play, and he has achieved a veritable triumph in the striking individuality which he has impressed upon each of the multitude of figures, while preserving the common link of intellectual dignity which binds them together as the arhat or the men who merit worship" (Anderson). The Buddhist school of painting continued to a recent date, but fire and war, and the decadence of religious sentiment, have brought about gradually the extinction of the school, and the destruction of a large proportion of its best productions. The Japanese Government are becoming alive to the importance of preserving the traditional treasures of the past, and the conservation of those which are still extant may be looked for. The few works extant of the earliest and greatest masters are already regarded with an almost religious veneration. To this it may be hoped will be added an intelligent historical sense of the importance of collecting and preserving them as artistic monuments. When we contrast the Buddhist school with the secular paintings of the Japanese academies, to which I shall now pass, you will at once notice that the Buddhist paintings are characterised by the lavish use of gold, and a rich combination of strong body colour, without any trace of *chiaroscuro;* such a combination of gold and black with strong primary colours required all the sense of colour which the Oriental artists possessed, to prevent their effects from being harsh, crude, and glaring. You must judge of the Buddhist art, not by the European standard or by comparing it with any other school than its own; you must remember its materials, its limitations, its want of science, and its strictly limited traditions. Under any circumstances you will admire the solemnity and sincerity and the religious sentiment of Kanaoka and Cho-Densu.

YAMATO AND TOSA SCHOOLS.

The essentially native school of Japanese painting, known as the Yamato school, is a Japanese modification of Chinese art, and its earliest and most prominent founder is named as Kasuga Motomitsu, at the beginning of the 11th century, but, as we have seen, Kanaoka himself, in the 9th century, drew horses and landscapes, as well as sacred subjects, and it is certain that Motomitsu learnt painting from the followers of Kanaoka. In the 13th century, one of the most famous artists of this Yamota school, Fujiwara No-Tsunitaka, assumed the title of Tosa. This native or Yamato Tosa school is one which resembled in its main characteristics the Chinese school, but they painted with finer brush; they adopted a conventional, stiff, and very incorrect rendering of the human form. The majority of their pictures have much of the character of Missal paintings, and are harmonious and elaborate in drawing, and very rich in colour, but with few exceptions. I cannot profess to feel myself in sympathy with the work of this school of artists, and in showing you some of their productions I do so as a matter of at least as much archæological as purely artistic merit. You will recognise delicacy of brush, richness of colour, and some power of characterisation, but the court ceremonials, with pictures of wearisome and unnatural stiffness, and absence of freedom of design, force of attitude, or depth of sentiment, testify only too strongly to the heavy fetters which a strict conventionalism imposed upon a school of artists which certainly possessed great skill of brush and sense of colour, and skill in drawing details.

CHINESE SCHOOL.

The Chinese school was undoubtedly the first of the pictorial schools of Japan, and as I have mentioned, it was the impulse of Nan-riu and the study of the pictures of the earliest Chinese painters which originated the secular school of Kanaoka, as well as the Buddhist pictures. But the Japanese diverged from the Chinese traditions, and developed, through the original genius of Kanaoka, and in the style of the native or Yamato-Tosa school, qualities which obscured the characters of Chinese painting; nevertheless, from the 9th to the 14th century, there were many of the Japanese artists who preserved the Chinese traditions. In the 15th century Mosetsu, a priest of Kioto, established an academy for the study of the works of the artists of the Sung and Yuen dynasties of China. It is doubtful whether he was of Japanese or Chinese origin. Of his pictures, examples are rare, and I have never seen any, and am not aware that there are any in Europe; but three of his pupils, Shiubun, Sesshiu, and Kano Masanobu, became renowned, and two of them, Sesshiu and Masanobu, founded schools which have had enduring influence and original character of their own. You will find authentic examples of these masters in the collection. To appreciate the works of this school, it is necessary to remember that they are to be judged from quite a special standpoint. They belong in their origin to what is known as the caligraphic school. Among their favourite subjects are landscapes idealised, frequently painted in monochrome, vigorously outlined with a free brush, destitute of perspective, and wholly opposed to any naturalistic rendering of landscape effects; nevertheless, the effects of distance and of atmosphere are produced by delicately graduated washes of diluted Chinese ink. The favourite subjects of Chinese story and mythology, the Rishis, the sages, the mythical trees, the dragons, the tortoises, the moon and plum blossom, the peacock and peony, or the lion and the peony (king of beasts, and king of flowers or of birds), the Buddhist saints; the revelry of the red-headed shojos and imps of alcohol; the tiger with the bamboo in whose jungles it hid; birds and flowers; anthropoid metamorphoses of the fox; the shokei or demon queller; the eagle and the hawk; the crane; the wild goose; the carp incessantly returning to its task of jumping the falls (emblem of undaunted courage), destined sometimes to be rewarded by success, and by transformation into the dragon shape and assumption to the clouds: the mandarin duck who pines to death for a lost mate and is the emblem of conjugal fidelity; Daikoku (god of wealth) striking the earth, with whose hammer strokes the bag fills with rice; Jurojin with his supernaturally elongated head significant of his vast wisdom; Hotei ruling in vagabond jollity with his lucky bag and attendant group of playful children. These are all subjects which recur again and again in the pictures of the Chinese school, all of which have their mystic symbolism and their attractive appeal to religious sentiment, to traditional sympathies, or to associated ideas of poetry, of natural beauty, or of quaint humour. Like subjects are found in the other schools of painting. In the Chinese school they interest us especially as being portrayed in the style of the artists of the middle empire who first originated most of these traditions and ideas, and whose caligraphic style was particularly adapted to render them with unforced felicity.

Sesshiu, who founded a school known specially by his own name, was strictly a follower of the Chinese school of Tang revived in the 15th century in Japan. It is told of Sesshiu that the priest under whom he was placed vainly endeavoured to give an adequate religious training, and insisted, fruitlessly, on his abandoning his artistic tastes. One day, however, he tied him to the temple pillar, his hands fastened behind him, as a punishment for idleness. On returning, he found he was gone, and on the floor were fragments of the rope and a number of rats, which scampered away. The explanation which the young Sesshiu was able to give, was that he had beguiled his weariness by drawing pictures of rats on the ground with his toe, and that these had presently started into life, and had gnawed the cord with which he was bound. After so distinct an indication of the artistic vocation, Sesshiu was of course left free to follow his inspiration. He became a pupil o Yosetsu, and then passed into China, where he studied Chinese painting and its source. His work is celebrated for its freedom, breadth of design, and poetic suggestion. There is a famous group by him of children at play, which was exhibited last year in London to the few who are interested in ancient Oriental art. It is reproduced by M. Gonse. I have no specimen of Sesshiu's work, but I can show you here a landscape by Keishoki, a pupil of Sesshiu, who flourished at the end of the 15th century, and whose landscapes greatly resembled those of Sesshiu, and are almost equally celebrated; and there is here before you his picture of the Shoki, or demon queller, which is interesting as being intermediate in style between that of Sesshiu and of Kano Masanobu, fellow-pupil of Sesshiu, who became the founder of a new school, of which I have now to speak to you, and which has been known, from the 15th century to the present time, as the Kano school.

THE KANO SCHOOL.

The Kano school was founded by Kano Masanobu, born about 1424 – a pupil, it is said, of Skurbun and Sótan. His son, Motonobu, became the actual head of the school. He was born 1477, and has been ever since recognised in Japan as the greatest of the Japanese painters of the 15th century, and as the chief founder of the vast reputation of the school. He was the friend of Goto Yujo, the Benvenuto Cellini of the 15th century, of whose metal work you find specimens below. He was married to the daughter of Mitsushige, and his fame then and since spread throughout the country. He received the honorary title of Hogen, and is habitually referred to as the Ko-Hogen or ancient Hogen, to distinguish him from the numerous artists who later received the like honorary title. In Motonobu we see the highest development which Japanese genius attained while working in the chains of the Chinese caligraphic style. His work is dashed in with the free brush and firm rapidly drawn outline, which were thought to be the highest achievements of artistic skill by the painters of this school; but in this picture of the Rishi Tekhai exhaling his soul (his spiritual essence), (Cat., Kakemono, No. 14, reproduced in Anderson's "Pictorial Glyptic Arts of Japan") and in these delicate paintings of birds and flowers, Kakemonos 11-16, you will recognise a true artistic genius which illuminates his figure sketches with life vigour, and which gives to his landscapes and flower pictures a tender sentiment far removed from any merely artificial school. Travellers in Japan ascending mountains and hill tops, whence beautiful views are described, come frequently to monumental stones, beneath which is said to be buried the pencil of Motonobu; for so much was his pictorial genius venerated in Japan, that in many spots celebrated for the natural beauties of the view the tradition long lingered that Motonobu standing there had endeavoured to depict the natural beauties of the landscape, and impatient at the difficulties which even his genius felt in fixing on the paper the evanescent beauties of the scene, had thrown to the ground his pencil, which was buried beneath this monument. The prevalence of this fanciful tradition in various localities testifies of course only to the wide-spreading fame of Motonobu and to the traditional veneration for his talent. I am fortunate in being able to show you several authentic specimens of the rare work of the great artist who is known as "the Raphael of Japan." Next to Motonobu in talent, in this school, ranked Tanyu, in the 17th century. Tanyu was the grandson of Eitoku in the 16th century, who was himself the grandson of Motonobu. Tanyu was one of three orphan brothers, and in his childhood the fame of the school of Kano had greatly declined. All three of the brothers, Tanyu, Naonobu, and Yasunobn showed great pictorial genius. The story runs in great detail that they were brought up and carefully trained by their grandfather, Eitoku, in the traditions of the school of Kano Monotobu, but in order that they might not fall into servile imitation, they were trained apart from each other. They were taught to go direct to nature for their inspiration, and lest they should become too strictly imitative, they were not even allowed to see each other's work. Tanyu was the most famous of the three and rose to the highest honours of the State to which a painter could aspire. He received the title of Kunikuo Hogen, equivalent to that of minister of the imperial household, and to a higher grade than that of Hogen. His generosity was equal to his fame and wealth, and many stories are told in illustration of it. His ablest pupil was Morikuni, who was very dissolute and untrustworthy, and acquired the bad habit of not only skilfully imitating his master, but of forging his signature. To wean him from this habit of too close imitation, Tanyu dispatched him to a distant province, with ample means for spending time in original study direct from natural sources. After a year or two he visited the district, and on arriving he made himself known as Tanyu to the innkeeper at whose house he stayed. This statement, however, was received with derision. Tanyu, they said, is already here; we have one of his paintings in the house, and he is too well-known and is too highly esteemed in this district for an impostor to have any chance of imitating him. Brought in front of this picture, Tanyu recognised the work of his errant pupil, but rather than expose him he endured the humilation of a supposed impostor, and at once returned home. The early work of Tanyu is that almost of a miniaturist, so minute was his drawing and so careful his study, and his earlier pictures are said to be very much in the manner of the Chinese artists. His later pictures, however, are impressionist in the highest degree, and an album which I have in my possession painted by Tanyu shows an extraordinary power of brush, in giving, by a few almost shapeless blotches and strokes, impressions of mountain scenery shrouded in mist, of lakes on which float shadowy boats, and defiles across which pass processions of travellers. One of the drawings is reproduced by Anderson. Examined closely, they are nothing but rapidly touched-in blotches of Chinese ink, sometimes a thin wash and sometimes a rapid and heavy blot; but looked at from a distance, there are poetic effects of mountain, lake, cloud with the most poetic impressionism, which artists skilled in the brush will recognise—a work only possible to a man thoroughly skilled, in the first instance, in a minute knowledge of natural form, and perfectly sure of himself, and secure in the results which he could produce by the slightest means. It is impressionism carried to the extreme; one which our latest 19th century artists here and in France recognise and sometimes reproduce without always possessing a perfect knowledge of artistic effect, and the security which Tanyu acquired by elaborate drawing and persevering study in his early life. There are many fine examples of Kakemonos by Tanyu in the collection of the British Museum.

SCHOOL OF MATAHEI (POPULAR).

Early in the 16th century Matahei, a pupil of Mitsushige, one of the masters of the Toza school, set himself free from the formal influence of that academy, and began a school of popular painting purely Japanese, which is most habitually recognised in Europe as characteristic of the genius of the people. Departing from the traditions which confined an artist to depicting ancient traditional subjects, court ceremonials, historic and legendary personages, he became interpreter of the national life of the people, and of the figures which he saw around him. The specimens of his work at this later period of his art are as rare as they are refined, and are highly prized. I have been able to obtain the example which I show you, than which it is generally admitted no finer exists (engraved in Anderson's "Pictorial Arts").

In this picture of the 16th century by Matahei, you will recognise a delicate draughtsmanship and a vivid and life-like characterisation; while the harmony and delicacy of colour are equal to anything which contemporary art has produced. Two of his most famous followers are—Moronobu, of whose works I have no specimen, and Choshun, to whose brush we owe the brilliant but harmonious and graceful picture of the Japanese lady in full costume which hangs before you, and which has been beautifully reproduced in coloured chromolithograph by Mr. Audsley in the fourth part of the "Ornamental Arts of Japan." Moronobu was the first artist of repute who made a speciality of book illustration, and the first signs of the great powers of the Japanese engravers are found in the illustrations of numerous books of Moronobu interpreting the life of the Japanese gentlemen and gallants of his time, as well as in the illustration of poems, scenes of Japanese story, and drawings of beautiful women. I shall have presently to refer again to this school of illustrators, but, meantime, I must complete the outline which I have to give to you of some of the leading painters of kakemonos.

SCHOOL OF KORIN.

Korin was the outcome of the school of Koyetsu. Koyetsu was a man of original genius belonging to the Tosa school, born at the end of the 16th century, and who died in the middle of the 17th century. He was at once a pictorial artist bred in the traditions of the Tosa academy, a man of letters, an eminent expert in what was then a special department of knowledge, the forging of sword blades, and the determination of a history of the ancient swords; a great chajin, or master and expert in the tea ceremonial, and skilled to a high degree in the decoration of lacquer. I have spoken of Koyetsu, in speaking last week of lacquer, in which he originated a new and bold school of decoration, in which Korin, on the one hand, and Sotatsu on the other, his two most distinguished pupils, became accomplished masters, and founders of a distinctly-original and masterly school of decoration. Ogata Korin, who died in 1716, at the age of fifty-six, was essentially a decorative artist, remarkable for the vigorous adoption of an internationally flat and conventional style of drawing, audaciously impressionist, but possessing great resource of colour and striking originality. I show you three kakemonos from his hand, the one a strictly decorative design of peonies and leaves, and the other of birds and flowers (26-29). It is as unnecessary as it would be difficult to describe a style so purely original and conventional as that of Korin, and of which a merely casual inspection leaves a permanent impression upon your mind. This screen, in which the whole background is in skilfully varied tones of yellow gold, with masses of white chrysanthemum flowers, formally treated and raised in low relief, enriched with springing green leaves treated with consummate firmness of line and decorative skill, is one of the finest known specimens of the style of Korin as a decorative artist, and is a noble work characteristic of the sense of colour and design peculiar to the Japanese genius. Of Korin's work as an artist in lac, and the school which he founded, you will find numerous examples in this collection, and I have already referred to his influence in founding a school in lacquer as in painting. His brother Kenzan, the famous artist in pottery, came under his influence as a painter and as a lacist. I have shown you some of the rare specimens of his lac, and much of his work as a potter. The Kakemono representing dogs at play (Kakemono, No. 29) is a good example of Kenzan's highly impressionist style as a painter, and perhaps you will think it is carried to too great an extreme, but studied with some sympathy, and at a distance at which its qualities can be appreciated, no one can deny its masterly skill. A contemporary of Korin was Sotatsu, whose delicate brush work is exemplified in this picture of street mummers masking and dancing (No. 22). According to the traditions of the records of the school of Kano, Sotatsu, and indeed Korin belong to the teachings of that academy, and were pupils of Kano Yasanobu. It is a tradition of the Japanese books, and it is the theory to which Mr. Fenalosa following the Wakusho-gwa-shiuran maintains, and to which he gives his critical adherence. I would by no means enter into the lists with Mr. Fenalosa, whose knowledge of the practice and history of the historic schools of Japanese art is profound, and based upon long continued studies and the examination of an immense number of examples of the works of the Japanese artists in his own collection, and studied on the spot in various localities in Japan, but I confess that in the work of Sotatsu I can discover no similarity whatever to any of the works of the Kano school, and no trace of the influence of their style. That, however, is an academic discussion into which you will not care to enter. The school of Korin had but few followers among the painters, but it was revived by Hoitsu at abont the beginning of the present century, who published collections of the designs of Korin, and established in the beginning of the century a new Korin academy, which rescued from comparative oblivion this original and characteristic branch of Japanese pictorial art. I show you three works of Hoitsu (Nos. 43-45), in which you will recognise the decorative style, and the rich instinct of colour little inferior to that of the master.

THE NATURALISTIC SHIJO SCHOOL (SCHOOL OF OKIO).

The naturalistic school of Japanese art may be said artistically to commence with Okio (born in 1732). Of the work of this most famous master you will be able to judge by the picture which I put before of the three puppies at play (No. 32); by this picture of the winter flight of Tokiwa, mother of the two lads, Yoritomo and Yoshitsune, destined to become the founders of a great dynasty of shoguns (No. 33); while by the landscape (No. 34), and in a less degree by the fox (No. 35), you will see how far he departed from the traditions of the Chinese school in which he was probably bred; how true to nature; how perceptive of the grace of animal forms; how refined and harmonious in colour, and how just in balance. I think no picture in my collection attracts more general admiration from the quite uninitiated observer than do these products of the brush of the great founder of the naturalistic school. It is recorded of Okio that his faithful study of nature led him habitually to consult peasants and unlearned persons as to the impression produced on them by his pictures, and there are many curious traditions of his sacrificing some of his best works to the pointed criticisms of merely peasant critics. Among the mass of more or less clever imitations of Okio, which the popularity of his style, and the attractiveness of his subjects has produced, it is not always easy to discern true from false Okios. There are probably as many spurious Okios and Sosens in existence as there are sham Rembrandts and Vandykes, and before paying a large price for a kakemono, either of Okio or Sosen, it is well to refer them to an expert in order to be sure that you are not acquiring a merely clever imitation. His seal is unscrupulously forged, and his style is still dexterously reproduced. I have mentioned here incidentally the name of perhaps the most celebrated master of the naturalistic school in animal painting next to Okio, Sosen. Sosen was born in the year 1746, and died in 1821. He was an animal painter of wide range, but his favourite subject was the ape, and he is especially noted for his drawings of monkeys. He has two styles: the one delicate and sometimes elaborate, the other rough and impressionist. The panegyric of Sosen is in the mouth of every one now. His original works are sought after by all collectors of Japanese painting, and they speak directly to every eye. He approaches more nearly to the European standard of naturalistic painting than perhaps any other Japanese artist; the humour and malice, the human passions of affection, greed, and maternal love, the quaint attitudes and anthropoid characteristics of the monkey have never been depicted with equal fidelity and sympathy (36 to 39). The pictures I put before you speak for themselves, but here also you must be aware of the innumerable forgeries with which the demand for Sosen's work has flooded the European market. His son Sosetsu rivalled his father, but never equalled him. There is an artist, Gansen, of the highest talent, who imitated Sosen with the utmost skill, and it is unfortunate that he should have carried his imitation to the extent of habitually applying Sosen's seal to his own work, which has quite sufficient merit, as this picture signed by himself in his own name will show you, to stand on its own merits. There is one little characteristic which will assist you, apart from study of the brush work of Sosen, to distinguish the imitations from the originals, and that is that Sosen recognised very clearly the peculiar angularity of the joints in the ape, and you will find it always well marked and defined. His imitators failed in this respect, and in most of the imitations you will find a roundness of the articulations of the arm and leg which is untrue to nature, but which is very general in all forgeries which I have seen. So, for instance, in the admirable reproduction in chromolithograhpy in Mr. Audsley's last beautiful work on the "Ornamental Arts of Japan," it is quite easy for the expert to see, even in the chromolithograph, that that is a reproduction of a clever forgery of Sosens and not of an original work. I am drawing now to the close of the pictorial line. Next to Sosen must be placed Ippo, celebrated for his drawings of birds and flowers; an artist of the early part of this century, whose picture of a bird and cherry blossoms (No. 55) you will admire as belonging to the most successful efforts of the school. Hoyen, also a bird and flower painter, of consummate skill, whose son is still doing very good work, but of a more degenerate character (52-53), and Keibun, whose bird drawings are excellent, but of him I cannot show you at present an example. There is one original artist, a contemporary of Okio, who founded a school which is known by his name, Ganku. The style of Ganku is in its origin essentially Chinese, imitating the artists of the Sung dynasty. His powerful drawing and specialties of colouring gave him a great reputation (especially in the drawings of tigers), and established him as the head of an academy at Kioto, in which he had some noted followers who adopted the first part of his name, according to the Japanese custom, and were known as Gantai, Gantoku, and Ganrio. I come now to the school described as the artisan or Ukiyo school.

THE UKIYO SCHOOL.

This school shone most especially in its engravings and illustrated books. As was the case in other branches of Japanese art, the first engravings of Japan were Buddhic images accompanying short prayers, engraved on wood, and hand-printed on paper. The Buddhist Bibles are often accompanied by illustrations, but in later days the glory of the great school of Japanese book illustration belongs principally to the popular school, and to the school of Kano. In the popular school, Hishikawa Moronobu illustrated a number of works which were delicately printed with fine black ink, between 1670-1700. Copies of these are rare, and highly valued.

The pupils of Moronobu developed this branch of art in Yedo, and towards 1700 Torii-Kiyonobu and Okumura-Masanobu extended the renown of this school.

At Osaka, an artist of Kano, Tachibana-Morikuni, published successively a series of about twenty works, which appeared in more than 100 volumes.

At Kioto, Nishikawa Sukenobu illustrated books of poetry. His drawings are studies of manners remarkable for their grace. Fashion and the rivalry between the three great cities tended to help to raise the xylographic art of Japan of this period to a pitch of great perfection.

An artist of Yedo, Suzuki Harunobu, who had already published illustrated books of the most exceptional talent, occupied himself with perfecting colour printing; a process which had, however, been employed at least as early as 1695, though it is not known by whom it was originated. Some documents ascribe the credit to Moronobu, others to Tori-i Kiyonobu. and others to Nishimura. These illustrated sheets, which were usually coloured red and powdered with gold, are, however, of a somewhat primitive character. Much study, and many experiments, had prepared Harunobu to take advantage, in 1675, of an opportunity which occurred at the great Shintoist festival which took place at the temple of Yushima, at Yedo. Two young girls performed on that occasion in the sacred dance in the temple with great success, and Harunobu published coloured wood engravings of these dancers which were much in advance in the perfection of colouring and drawing of anything which had been seen, and achieved great fame. He then successively published a series of coloured works, which opened a new period in the history of this popular Japanese art. Soon his contemporaries began to use to advantage the new invention, and among these, Kita-wo-Shigemasa and Katsukawa Shunsho distinguished themselves. They published a magnificent series of books illustrated with coloured engravings, preserving, in the first instance, the *format* of Harunobu.

An artist of the Tori-i school struck out a new line, and made further progress. This was Seki Kiyonaga. He enlarged the size, and issued plates composed of three sheets. In the work of Kiyonaga the design, colour, and grace of line leave little to desire, and the form which he adopted in 1775 has remained the classic model for the subsequent schools of Japanese engravers and colour printers. The tone and colour of Kiyonaga was continued by the great draughtsman who followed him, and who produced the most remarkable works, such as Kita-o Masayoshi and Kita-o Masanobu (both of the school of Shigemasa), Hosoda Yeishi, Korûsai, Kitagawa Utamaro, Utagawa Toyokuni.

Shunsho adopted a special form in his colour drawing, long and narrow, and in this form he published a long series of representations of dramatic scenes and celebrated actors. His pupils, Shunko and Shunyei, were almost as skilful as their master. During this period the school of Tori-i continued to publish flying sheets of coloured engravings of theatrical scenes, and portraits of actors in the old form, with inferior colouring, and on paper of secondary quality. Kiyomitsu, however, a master of this school, has produced very graceful drawings, notwithstanding these defects. An artist named Ippitsusai Buncho adhered to the colouring of Harunobu, and the *format* of Tori-i. His drawings of actors push the affectation of grace even to feebleness, but there is something exceedingly refined both in colouring, and style, which is peculiar to Buncho.

A young artist, who became the pupil of Shunsho, and whose first career was that of a man of letters, showed quickly extraordinary artistic talent, and renouncing the literary career, became the popular artist of his time, and has left a reputation which has overshadowed that alike of his predecessors and of those who followed him. This was Hokusai. He published a long series of illustrated books and coloured sketches towards the end of the 18th century, which produced an extraordinary sensation in the artistic world of Japan from the individuality of design. The marvellous fertility of his imagination, and the power which he possessed of representing every variety of subject in the range of ordinary life and of nature, with truthfulness, humour, and unerring accuracy of design which have never been surpassed.

The works of Hokusai have achieved so world wide a reputation, and have been the object of such careful study by nearly every one who has written in the pictorial and xylographic art of Japan, that I needly only refer you to the monographs of M. Duret, to the chapters of M. Gonse, and to the pages of Mr. Anderson for his eulogium. Mr. Whistler, in the peroration of his address on art last year, spoke of Hokusai as the greatest pictorial Japanese whom the world has seen since Vandyke. His drawings form the staple of the illustrations of Reed, Alcock, and others in their chapters on pictorial arts. I put before you not only a number of his surimonos and sketch books, hand-printed from his drawings, but I am also able to show you a remarkable specimen of his hanging pictures or kakemonos, in his picture of the Oukumi expelling the house demon on New Year's-day with a shower of beans. This has been admirably reproduced by Mr. Audsley in a chromolithograph in the "Ornamental Arts of Japan." I am further able to show you this unique collection of upwards of forty drawings made by Hokusai for a work which he had projected, but of which only a part was published, illustrating "Extracts from the One Hundred Poets of Japan." The existence of these drawings was unknown either in Japan or Europe, and they constitute an unique treasure. They came into my possession quite recently, with documents absolutely confirming their authenticity, which, however, requires no confirmation. You have only to look at the marvellous accuracy and rapidity of the draughtsmanship which is visible in every line of them, the certainty and delicacy of touch, the infinite fancy and the genius which they display, to satisfy yourselves that they are from the hands of an unsurpassable master—one in whom the *vis comica* is often carved to the point of caricature, but who is quite unique in his fancy, his skill, and his method of execution, and who largely deserves the enthusiasm which is lavished on him. These drawings, like most of Hokusai's works, were intended to be cut in wood, and were drawn upon thin paper for this purpose. Had the work been completed, they would have been destroyed, as have been the others of the series which were published. The process of the Japanese wood engraver was to affix the original drawing to the blocks, so that the original drawing was destroyed in the act of cutting the block. It is only owing to the circumstances that the intention of completing the work (of which the first half has been published) was abandoned, that these drawings still exist in their original state as a precious memento of the handiwork of this great master. I have been applied to by M. Gillot, of Paris, to allow them to be reproduced by one of the modern photographic processes, which will, of course, in no way injure the originals; and as I think it will be churlish not to facilitate the reproduction and publication of these delightful and hitherto unknown series of sketches, I have with pleasure consented. Many of the most exquisite productions of Hokusai are coloured sheets known as surimonos. Surimonos correspond, only in a more artistic fashion, to our New Year's cards. They are flying sheets of illustrations, the production sometimes of an accomplished artist, sometimes of an amateur, carefully printed by hand in colour, and were sent to friends on the occasion of the New Year's-day. Hokusai was distinguished above all others in the production of these surimonos, and some of his most exquisite and artistic designs are in this form. Some of them are delicately produced in M. Gonse's book. The year 1804 was a year of general festival in Japan, and New Year's-day was celebrated with great pomp on that occasion, for in the lunar calendar of Japan the ages are divided by a series of sixty years, and 1804 was the first year of a series corresponding in the Zodiac to Kinoyé-Ne, an emblem of Daikoku, the god of prosperity, and this, therefore, was looked forward to as a good year, which would bring happiness and fortune. Surimonos were largely produced this year, according to the fashion which had commenced in the 18th century, as a sort of luxurious visiting card exchanged on the New Year's-day, and Hokusai put forth his greatest efforts to meet the demands of his patrons. The surimonos of Hokusai are among the most exquisite products in colour printing which are known to artists. Hokusai's surimonos have been collected with great avidity at high prices, and although he produced a considerable number, they are now very scarce and difficult to obtain. The pupils of Hokusai, such as Hokkei and Gakutei, also issued exquisite surimonos.

From this date the large *format* which Kiyonaga had introduced passed into hands of the popular artists, and became universally adopted through the efforts of Toyokuni and his school. They were skilful draughtsmen, and produced remarkable coloured sheets, but the great demand for them and the low price at which they were sold, brought about a gradual decadence both in colour and finish. Hokusai produced, in addition to these coloured engravings, a considerable number of book illustrations either in black, or black slightly coloured, and a selection of his works is an illustration of the whole life and nature of Japan in his days. The whole list of the works of Hokusai is hardly yet authoritatively made out. To understand fully the genius of Hokusai it is necessary to follow the whole range of his most fertile genius.

Ichirûsai Hiroshigé was an artist who published some interesting series of coloured wood engravings, among which especially are a series of studies of landscape on the route of the Tokaïdo, which are much esteemed by reason of his having introduced better elements of perspective than his contemporaries.

The school of Toyokuni was continued by Kunisada, an able artist, who adopted the same name. An artist who also greatly distinguished himself as an engraver in colours at the beginning of this century was Kuniyoshi. Haségawa Settan was a designer, who illustrated, among other things, the twenty volumes of Yedo-meisho with talent. Of many of these you will find examples in the collection which I have placed in the Library.

Illustrated books and coloured engravings have fallen into a state of great decadence in Japan for the last twenty years, and the specimens which are now produced are very apt to be crude and violent in colour, rough in execution, and imperfect in drawing.

(To be continued).

CANTOR LECTURES.

ANIMAL MECHANICS.

By B. W. Richardson, M.A., M.D., F.R.S.

Lecture I.—Delivered May 3rd, 1886.

Animal and Ordinary Mechanisms Considered and Compared.

(Abstract.)

After a brief introduction, in which the lecturer defined as natural or vital mechanics those mechanisms which are produced by nature without the interposition of man or any animal inferior to man, he showed on the screen a series of photographic and diagrammatic illustrations of numerous natural mechanical parts — the valve, the lever, the camera, the pouch, the screw, the tube, the vesicle, the column, the cord, the pulley, the muscle, and the joint. He then drew a comparison bearing on originality of design between natural and human genius for invention. On this subject there are two views: one, that natural and human inventive skill are independent of each other, though alike in character; the other, that human inventive skill is an imitation or copy from the natural—an idea which even men of scientific attainment had supported.

Dr. Richardson, in treating on these two hypotheses, while admitting that man could not be said to have invented anything that did not exist in nature, and therefore only re-created the created, and while also admitting that in many mechanical works of nature man might find many copies, maintained, nevertheless, that the human faculty for mechanical invention is quite independent, and that man, in invention, as often re-copied from himself without intention as he did from nature, also without intention. As an artist, man is an imitator; as an inventor, he is original; the phenomena included in mechanical problems being to him abstractions, like good and evil, space and time. In support of this view Dr. Richardson urged the following reasons:—1. That if man in his inventions were a mere copyist, he would rank lower in this respect even than insects, which were mechanics, but certainly from no studied imitation from natural objects. 2. That if man had learned all his inventions from the inventions of nature, he would have been a naturalist first and a mechanician afterwards; but in fact, he is a wretched naturalist; a splendid mechanic. 3. That the attempts of man to copy from nature in mechanical work had been amongst the least successful of his mechanical results, as shown in his attempts from and even before the time of Borelli to make a flying machine. 4. That the skill of man in all his great mechanical results is cumulative, has its origin in the smallest beginnings, and progresses step by step onwards by human skill alone. This was illustrated in the development of electricity, from the first experiment of children rubbing pieces of amber up to the telephone and microphone, in the whole of which mighty development, although the phenomena and their causes might be found in nature, man stood alone as the inventor, without going to nature for any copy of her designing. 5. That if man had been a direct copyist from nature, in his mechanical work, he would not have produced such perfect mechanisms as those which he has constructed, since it is one of the most remarkable of facts that many of the most important natural instruments (for example, the eye-ball) are imperfect in details of construction, unfinished, to use a workman's term, and liable to deviation in action. On the whole, the evidence is in favour of the belief that man is endowed with independent powers of invention. This, however, does not take away from the study of nature as a teacher. Her apparent errors may be guides; she may reveal secrets if she be carefully followed; she may certainly suggest economy of power and of adaptation; and she is ever deserving of consultation as the omnipresent and primitive mechanical organiser and worker.

Lecture II.—Delivered May 10, 1886.

MATERIALS FOR CONSTRUCTION.

(Abstract.)

The materials used by nature in her mechanical works, are so distinctive that we might from them form a fair conception of the physical condition of the planet at the time when natural mechanics began to have an existence. The number of parts entering into the natural constructions—fewer than those used by the man in his works—were considered first from their elementary forms and afterwards from the compounds produced by the elemental combinations. The elements used by nature were divided into four groups:—(*a*) The gases: oxygen, hydrogen, nitrogen. (*b*) The non-metallic solids: carbon and sulphur. (*c*) The metals: calcium and iron. (*d*) The metalloid: phosphorus. The respective uses of these elements were briefly defined, with the explanation of an experiment made by Dr. Richardson in 1869, in which all the elements, except the carbon, that formed the body of an animal, a smelt, were dispersed by the immersion of the dead animal under molten lead. The carbon remained intact, and floated to the surface of the molten lead in the precise form of the animal, as its mechanical elementary skeleton, the solid basis of its construction. The uses of the elements are fairly known, except in regard to the metal iron. Iron, the lecturer said, is essential to some vital purpose, but what that purpose is he could not venture to state. It had been thought that iron had some relation to the colour of the chief fluid of animal organisms, the blood; iron had been supposed to be carrier of oxygen; he had himself supposed that it might be a conductor of an electrical current; but against each and all of these views there were objections which at present were unanswerable.

From the elements Dr. Richardson passed to the compound structures formed by elemental combinations and used by nature in her mechanics. He classified such compounds for study into seven great groups: (1) The gelatinous; (2) the resistant or bony; (3) the contractile — muscular; (4) the transparent — lenses and humours; (5) the receptive — nervous centres, screens, and cords; (6) the elastic—elastic tissue, wherever distributed; and (7) the aqueous—blood, fluid secretions, fluid excretions. The organs and mechanisms made or formed from the compounds thus specified were passed under review, and by the electric light there was shown on the screen a large number of illustrative designs, many of them direct photographs from the natural parts themselves. Under the first division of compound structures the membranous structures were surveyed as investments, as valves, as tubes, and as basements; they were followed by views of ligaments, cartilages, tendons, and fasciæ, and so on through the other groups, osseous, muscular, lenticular, nervous, and elastic. The lecturer indicated how the character of a structure might be changed by the introduction into it of even one new element, such as sulphur or phosphorus. He dwelt also on what may be called the natural choice or selection of elements for particular objects, as the light, malleable, strong metal calcium for the composition of the solid resistant structure of bone. He exhibited a table in which the elements used by man in his mechanical inventions were shown to exceed in number those of nature, while including all that she uses in her work. Then, dwelling on the notion of the ancient philosophers, that natural mechanisms were made out of four elements—air, water, earth, and fire—he explained that in a general sense the ancients were correct: for air yielded oxygen and nitrogen; water yielded oxygen .and hydrogen; the earth yielded oxygen, calcium, sulphur, phosphorus, iron, and carbon—altogether the material elements most wanted; while fire, or the motion which puts these elements into work, completes the series, and yields that endowment of vital property which leads to structure, form, independent action, motion of dead matter, life itself as manifested in its varied and infinite phenomena.

General Notes.

NATIVE INDUSTRIES IN SOUTH AFRICA.—The Zulu Kaffirs make a variety of pots and jars, some of very large size, out of clay, which they bake, and employ for holding their native beer, milk, and water. Some of the native boats at Delagoa Bay are built on the European model, with lateen sails; but the most singular are the boats made by the natives on the Usutu, and which are brought down to Lorenzo Marques by river. They are sewn together throughout, and approach, more or less, the European model, being straight or curved, as the planking permits. They have a flat stern and peaked prow, and leak considerably, despite a plentiful plugging of clay; yet the natives perform voyages of 100 miles in them by sea with safety. The oars are merely long poles, with a round piece tied on to represent the blade.

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FRIDAY, NOVEMBER 5, 1886.

All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

NOTICES.

SECTION OF APPLIED CHEMISTRY AND PHYSICS.

The Council, after careful consideration, have arrived at the conclusion that the work for the promotion of which this Section was originally founded in 1874, is now so efficiently carried on by the Societies specially established for the purpose (The Institute of Chemistry and the Society of Chemical Industry), that the necessity for a separate Section of the Society of Arts no longer exists. They have, therefore, decided to discontinue this Section, under the belief that the resources and the influence of the Society may now be better applied in other directions.

H. Trueman Wood,
Secretary.

ARRANGEMENTS FOR THE SESSION.

The First Meeting of the One Hundred and Thirty-third Session of the Society will be held on Wednesday evening, the 17th November, when the Opening Address will be delivered by Captain Douglas Galton, C.B., D.C.L., LL.D., F.R.S., Chairman of the Council. Previous to Christmas there will be four Ordinary Meetings, in addition to the Opening Meeting. The following arrangements have been made:—

November 24.—"Purification of Water by Agitation with Iron and by Sand Filtration." By William Anderson, M.Inst.C.E.

December 1.—Adjourned Discussion on the paper read by Dr. C. Meymott Tidy, on "Sewage Disposal." (Read April 14, 1886.)

December 8.—"Glow Lamps, their Use and Manufacture." By Major-General C. E. Webber, R.E., C.B.

December 15.—

Papers for which no dates have, as yet, been fixed:—

"Development of the Mercurial Air-pump." By Prof. Silvanus P. Thompson, D.Sc.

"Photographic Lenses." By J. Traill Taylor.

"Machinery and Appliances used on the Stage." By Percy Fitzgerald.

"Recent Advances in Sewing Machinery." By John W. Urquhart.

"Textile Fibres in the Colonial and Indian Exhibition." By C. F. Cross.

"Irish Industries." By Rev. Canon Bagot.

"Cameo Cutting as an Occupation." By J. B. Marsh.

"Adulteration of Beer." By A. Gordon Salomon.

"Miners' Safety Lamps." By Edward H. Liveing.

Foreign and Colonial Section.

The meetings of this Section will take place on the following Tuesday evenings at Eight o'clock:—

January 25; February 15; March 1, 29; April 19; May 17.

Indian Section.

The meetings of this Section will take place on the following Friday evenings, at Eight o'clock:—

January 21; February 25; March 11; April 1, 29; May 27.

Cantor Lectures.

The First Course will be on "Principles and Practice of Ornamental Design." By Lewis Foreman Day. Four Lectures.

November 29; December 6, 13, 20.

The Second Course will be on the "Diseases of Plants, with special reference to Agriculture and Forestry." By T. L. W. Thudichum, M.D. Three Lectures.

January 24, 31; February 7.

The Third Course will be on "Building Materials." By W. Y. Dent, F.C.S., F.I.C. Four Lectures.

February 14, 21, 28; March 7.

The Fourth Course will be on "Machines for Testing Materials, especially Iron and Steel." By Prof. W. C. Unwin, F.R.S. Three Lectures.

March 21, 28; April 4.

The Fifth and Concluding Course will be on "The Structure of Textile Fibres." By Dr. FREDERICK H. BOWMAN, F.L.S., F.G.S. Five Lectures.

April 25; May 2, 9, 16, 23.

JUVENILE LECTURES.

Two Juvenile Lectures on "Soap Bubbles," by Prof. A. W. REINOLD, F.R.S., will be given on Wednesday evenings, January 5th and 12th, 1887, at Seven o'clock. Special tickets will be issued for these lectures.

Proceedings of the Society.

ADDITIONAL LECTURES.

JAPANESE ART WORK.

BY ERNEST HART.

Lecture III.—Delivered May 18th, 1886.

(PART II.)

THE OLD JAPANESE PORCELAIN AND FAIENCE.

By the common consent of the students of keramic art, the Japanese were, and are, the most accomplished and artistic potters that the world has seen. In some departments they were excelled as artistic makers by the Chinese, their original masters. The fire and the brilliancy of the vitrified enamels, and the lustrous glazes of the old Chinese porcelain works have never been equalled. The monochrome porcelain of the Ming and Kienlong periods, the ruby, *sang du bœuf*, imperial yellow, crushed strawberry, peach bloom, moonlight blue, camellia green, apple green, and other rare enamel porcelain of old China always have been, and still remain, inimitable. They are as much admired, and even more highly prized, to this day in Japan than even in China or in Europe. Yet, strangely enough, it was to the quality of the porcelain of Japan that its great artistic fame was chiefly due in Europe during the 17th and 18th centuries. The peculiar kind of porcelain known in this country as old Japan ware, and described by Jacquemart as the "chrysanthemo-pæonienne" ware, was imported in great quantities through the Dutch monopolies of Deshima, and formed the delight of patrician buyers for upwards of 200 years. It was chiefly the product of the province of Hizen, and still forms the basis of the great collections of Dresden, and of most of the great houses and palaces of Europe. It is not to be undervalued. In some of the fine specimens, paste, glaze, colour, and decoration are alike admirable. The passion for it proved a mine of wealth to Dutch traders; but it was at the same time somewhat gaudy and monotonous in decoration. It was always a secondary product, manufactured exclusively to please the European taste, and in European sizes and shapes; the huge vases and *garnitures;* the great bowls, and the long series of plates of this old Japan ware had nothing in common with the Japanese taste, and are of little value now beyond their traditional interest, and the recollection of the part they once played in the decorative and domestic history of Europe. The glory of old Japan is its porcelain ware, the works of the private kilns of certain of the princes, and the choicest works of the old makers of blue and white and of Kakiyemon and Imari, which were little seen in Europe until the last thirty years. The specialty of the Japanese keramists was their faïence and hard stoneware, the Raku ware, Kutani, Bizen, Oribe, and old Satsuma. Of these highly characteristic specimens of the work of the old Japanese faïence, few specimens were seen in this country till after the downfall of the Tycoons. Happily, Mr. Franks, in this country, early appreciated the importance of studying the artistic pottery of old Japan. The collections at the South Kensington Museum, and those which he has just presented to the nation at the British Museum, are of great value in illustrating this previously almost unknown chapter in keramics; his excellent catalogues will dispense me from the necessity of much detail as to the individual potters and marks. I propose, therefore, only briefly to illustrate to you this novel and interesting subject by a running commentary on the succession of the chief schools and of the great masters; of which I am able to show you some of the most brilliant specimens.

BLUE AND WHITE PORCELAIN.—SHONSUI GORUDAYU.

To speak first of porcelain, which has, by a generally accepted European convention, received the first place in the keramic art, I would call your attention to some examples of the blue and white porcelain of Japan, the beauty of which is insufficiently appreciated, inasmuch as we have accustomed ourselves exclusively to admire the blue and white of the old Chinese potters.

The first introduction of the manufacture of porcelain into Japan dates back not earlier than 1530, when one Gorodayu Shonsui, of the province of Ise, travelled to China to learn some of the secrets of the porcelain makers of Foochow, and brought to Arita in Hizen the art of mixing and baking porcelain, and decorating it with blue under the glaze. He brought with him from China the clay, the glaze, and the colour, for at that time the ingredients of porcelain had not been found, nor were the secrets of compounding it known in Japan. Thus he was limited both in his methods and the amount of his product, but he showed considerable skill, and has an enduring fame as the father of Japanese porcelain. He made only blue and white porcelain under glaze, and his works were mostly small in size. I show you here an authentic specimen of the work of Gorodayu Shonsui; this small old diaper perfume pot or covered tea powder jar. It bears his full signature, and is authenticated by the best critics as an undoubtedly original and fine specimen. So far as is known, it is the only authentic specimen of the work of the father of Japanese porcelain existing in Europe. Two pupils of Gorodayu carried on his tradition, Gorohachi and Goroshichi, but for want of material the fabric languished, and its reputation declined until about 1508, when Risampei, the Korean potter, was brought by Nabeshima Naoshime, the ancestor to Prince Nabeshima, one of the Japanese generals of the Taiko to Arita; he found, on the slopes of the mountain, the feldspathic material, which was needed for the production of porcelain. For forty years blue and white porcelain continued to be made here, but the Japanese keramist did not acquire the art of using vitrifiable enamels, which required the second firing over the glaze at a low temperature—the secret of the Chinese coloured enamel porcelain vases.

PORCELAIN DECORATED OVER THE GLAZE. TOKUZAYEMON KAKIYEMON.

This was first introduced into Japan by a certain Tokuzayemon about 1647, who learnt the Chinese art. He, however, was not himself a skilful potter or artist, and it was his great contemporary, Kakiyemon, who having, it is said, acquired the secrets of Tokuzayemon, freed himself from the fetters of Chinese traditions, and produced porcelain decorated with designs in coloured enamel which created a new epoch in porcelain. Kakiyemon attained at once to a degree of perfection in the manner of decoration and perfection of porcelain, which has never been surpassed. His porcelain has a fine white hard base, which rings with clear bell-like sound. In the most beautiful specimens of his work, such as I show you in this basin shaped like a chrysanthemum, the milk-white glaze is sparsely decorated with finely drawn designs of the bamboo and the plum blossom. Sometimes his ware is decorated here and there with corn sheaves and flowers, and here and there with a fluttering bird. The colouring of his enamels is characteristic; generally it is in dull red, pale apple green, and lilac blue. You will recognise this basin, for example, as having been the parent of the famous ware of Dresden, of Chantilly, and of Chelsea—all of which factories, at a later date, so closely imitated the white porcelain and the decoration of Kakiyemon that, for many years, specimens of his handiwork being unfamiliar in Europe, it was difficult to distinguish the originals from the copies. I am able also to put before you an exquisite specimen of his modelling of porcelain statuettes. This statuette of Osugumo, a contemporary beauty and poetess, the friend of Kakiyemon and of Korin, is, as you will recognise, a masterpiece of sculpture in clay, in pose, in the grace of the draperies, and the life-like movement of the figure, in the beauty of the polychrome decoration and diapers of the robes, you will recognise it as a masterpiece—the historic forerunner of the famous porcelain statuettes of Dresden and of Chelsea. An original type, fresh from the hand of the Japanese who created it for the first time, it has been reproduced with all the modifications of European taste in a thousand different shapes, but has never been excelled; for the lover of keramic art and for the student of its history it has an undying attraction and a priceless value. Kakiyemon worked also in faïence and terra cotta, but of this I have no specimens to show you, and I know of none. This figure has been exquisitely reproduced by Mr. Audsley in his great work, in a coloured plate, which, I believe, is one of the best pieces of modern chromo-lithography, and in reproducing which thirty-seven stones were used.

THE PORCELAIN OF KAMEYAMA, HIRADO, AND NABESHIMA.

Making of blue and white porcelain, decorated under glaze at a single firing, continued to flourish at Imari, and in the collection you will see some specimens which rival in depth of transparency and in graduation of translucent cobalt blue, the fine work of the Chinese artists so much valued in their hawthorn pots. The artists of Kameyama and of Hirado also produced in the 18th century a blue and white of exquisite beauty; especially notable is the blue and white porcelain of Hirado ware. A private factory was established in 1740 by Matsura, a prince of Hirado, who watched over the products of his factory, and reserved them for presents to the Tokugawa princes and his private friends. This factory was established at Mikawa-uchi, hence was often called Mikawa-uchi ware. The porcelain was never in commerce, and is therefore excessively rare; in Europe it is justly highly prized. Capt. Brinkley calls attention to the extreme delicacy of the body of the paste, which he states was finely powdered, strained and purified, while the glazes were prepared with long and most minute care. The blue is pure and soft, different altogether from the intense cobalt of old Chinese ware. The delicacy of the drawing and perfection of the firing are not excelled, and by many considered to be unapproached, by any porcelain over all Japan or China. The white porcelain animals, birds, and figures of Hirado, and the sprays of flowers, all of this period, are of extreme beauty and value, representing in this collection as you see in them the direct progenitors of the products of old Dresden. I show you two fine specimens of Nabeshima ware, one of which is illustrated in the work of M. Gonse. Hirado ware is still produced, but it is now of a purely commercial character. The pieces are much larger and have excellent qualities, but they are wanting in delicacy of paste, in the beauty of the milk-white glaze. Of the pieces which I show you of the old ware, you will notice that several are engraved in the biscuit under the glaze, and that in delicate modelling and all artistic qualities, they are unsurpassable by any Chinese or European originals, while in general taste and freedom of design they are far superior to the old Chinese work.

KUTANI PORCELAIN.

Another famous school of porcelain is the variety known as the Kutani ware. Porcelain of Kutani was made at the village of Kutani, in the province of Kaga. It was commenced by Goto Saijiro, who was an artist in pottery and excelled in figures, whom Prince Mayeda sent in 1858 to Arita (Hizen) to study the production of porcelain. Saijiro, on his return, made only small pieces with the material which he brought from Hizen. The objects of this period are pure porcelain, decorated in red, green, yellow, violet, gold and silver. By subsequent experiments he discovered near the villlage of Kutani a clay which supplied the elements of success to the local factory. This discovery enabled the pupils of Saijiro to produce more important works. These artisans had not, however, the artistic skill to produce finely-decorated pieces. Kudzumi Morikané, the eminent pupil of Tanyu, came to Kaga towards the end of the 17th century, and gave the aid of his brush. He introduced freedom of design in the Kaga porcelain, and treated a great variety of subjects, as well as the Karako, or Chinese. These specimens of Morikané's work are highly appreciated. They are in peculiar tones of green, violet and yellow, and rarely red. This is the Ao-Kutani, or green Kutani. These were pure porcelain. Later in the 18th century the material degenerated, and the Kutani of this period is almost a failure, and the earthy base is very dark, almost black.

Later, Kutani entered on another period. In 1814, a certain Yoshidaya rediscovered in a Chinese work the technique of porcelain, and learnt the art of decoration with red, which Sayiro had discovered a hundred years ago, but which had been lost. He made, once more, red porcelain decorated with gold, which was known as Hachiro-ye, or designs of Hachiro, the name of the designer who decorated these objects. In 1878, Yeiraku Zingoro, of Kioto, came to Kutani, and began to make red porcelain brilliantly decorated with gold. The gold of Yeiraku was applied in leaf, and is very brilliant, and its red very clear; that of the previous period is darker, and the gold is applied in powder.

PORCELAIN OF OWARI, OR SETO PORCELAIN.

Seto, in the province of Owari, which produced so long pottery and porcelain, that it came to be known as Seto-mono, did not begin to produce porcelain till 1801, when a potter named Kato-Tamekichi, who had been to Arita, after four years study, returned to Seto and discovered porcelain earth. These are now the potteries which are the great sources of modern Japanese porcelain, and which are full of commercial activity. Its products have never been really artistic, although the workers were admirable artisans.

PORCELAIN OF KYOMIZU (A SUBURB OF KIOTO).

Unlike Owari, the Kyomizu-yaki is an artistic ware. According to Mr. Kurokawa Mayori, author of the chapter on porcelain in the work called "Kogé Shirio," published by the Museum of Tokio in the year 1868, Ninsei himself made porcelain at Kioto, in the 17th century, and later this branch of keramics was continued by Otobaya-Kurobé (1751 to 1763). However, the blue and white porcelain, called Sometské by the Japanese, was commenced at Kyomizu, between 1804-17, by Takahashi and Dohachi, Wangé, Kité, Midzukoshi-Yoché, are after the style of the porcelain of Hizen. These are highly artistic, but are not rare; and these are what are usually known as the Kyomizu-yaki. The signs by which it may be recognised are the relative coarseness of its paste, and the relative blackness of the thicker parts of its blue decoration. Although Yeiraku made porcelain at Kyomizu, it is known, not as Kyomidzu-yaki, but by his name, and is distinguished by his special red and gold decoration.

There are other kinds of porcelain, such as porcelain of Imno, Tozan, Nakano, &c., which are objects of collection, but which have not the same importance as schools and varieties, as those of which I have spoken.

But I must pass to faïence, into which the Japanese threw all their genius as artists, potters, and decorators, and in which they knew how to produce subtle and surprising effects, delicate gradations of colour, and quaint forms, which give to Japanese pottery a unique place in the history of keramics.

JAPANESE POTTERY AND FAIENCE.

The Japanese passion for Giogi art pottery dates back to the influence of Giogi and his successors in the 9th century. Japanese amateurs have for centuries cherished the richly-glazed celadon known as Seiji, copied from and rivalling Chinese originals; and in the 12th century Toshiro, a potter, of Seto, in the province of Owari, had brought back from his travels in China some of the famous little enamelled faïence tea powder jars and bowls which excited the enthusiasm of the Japanese, and became objects of a singular and almost idolatrous veneration by the Japanese nobles of successive generations. Traditions of the old tea ceremony, its slow and ceremonious customs, its political and social influence, are admirably told by Mr. Franks in the introduction to his catalogues. His collection of tea jars is unsurpassed. I show you a few specimens of the ancient tea jars and tea bowls, one of them, of the 15th century, bearing the description of Daibutsu-Hooji, which has the traditional fame as a cup of Taiko-sama, and was sent to Europe with a string of unneeded certificates. It is undoubtedly of the 15th century, and is a typical specimen of the somewhat rustic but subtly coloured enamels which pleased the Japanese taste, and which were traditional with this kind of ware. In the other specimens you will recognise the richness and depth of the glaze, and the subtle play of colours, but you will probably smile when you hear that such choice morsels of pottery were in past times in Japan the choicest gifts of a prince and the most treasured possession of a daimio; that they have been the cause of wars, vendettas, and suicides; and have been sold for many times their weight in gold—sometimes as much as £500 was given for a single specimen of great traditional fame. They come to Europe clothed in rich brocades, and enclosed even in more than one rich lacquer box. They have not for us the special historical attraction or peculiar grounds of veneration which they had for the old Japanese, but they are interesting as examples of an early and somewhat superstitious taste and of political and social fashions, rather than as specimens in themselves of any supreme beauty. There are many other varieties of Japanese pottery, of which you will find examples in the collection, and of which the history is recorded in Mr. Franks's catalogue, but on which I must not linger. You will find here examples of the early Shigaraki ware, singularly rough, but showing no small skill in potting, and a certain primitive beauty in glaze of the Soma ware with its impressed horse, the heraldic emblem of the Prince of Soma; the Takatori ware with its lustrous glaze, of which this Hotei is a fine specimen; the old Banko and Higo wares; the incised Yatsushiro, and the Kinko zan ware, with its rich raised blue enamels; Toyosuké in characteristic brown and white reliefs; the brilliantly coloured Oribe with flashes of mottle glaze, and the fine old Imbé or Bizen ware, with its rich reddish-brown salt glaze, one of the oldest of Japanese wares, and of which I show you some exquisite specimens, dating back at least from 400 to 500 years. Mr. Doulton would readily acknowledge that they are not even now to be equalled by his accomplished workmen, with all the appliances of the 19th century. Of the blue and white Bizen ware, I show you also some rare examples; but as time would fail me even to speak in outline of the history of these ancient art potteries and their founders, I must refer you to my printed catalogue, to the works which I have already mentioned by Mr. Franks, to the chapter on pottery and porcelain in M. Gonse, and especially to the great forthcoming work on Japanese porcelain and pottery by Captain Brinkley, of which we have a most appetising foretaste in the admirable notes included in the catalogue which Mr. Edward Greey, of New York, has published of the Brinkley collection at his art gallery. This promises to be by far the most complete and valuable work on the subject, and will be necessary to every student and collector. I have time only to dwell upon three great varieties of faïence, which are the masterpieces of Japanese keramic art, viz., Ninsei ware, Kenzan ware, and Satsuma ware. After Kakiyemon, Ninsei and Kenzan are the two great dominant names in the history of Japanese pottery.

THE WORKS AND INFLUENCE OF NINSEI.

Ninsei flourished from 1624 to the middle of that century. He was a contemporary of Kakiyemon, and belongs, therefore, to the golden age of Japanese decorative art. He was an artist first, and next a potter. He acquired the secrets which Tokuzayemon had a few years previously imported into Hizen of the Chinese art of working with enamels over glaze, a secret which, under the strictest penalties, Hirato factories vainly endeavoured to keep to themselves. Ninsei at once applied this art to the faïence of Kioto in 1653. He dealt with it in thoroughly Japanese taste, and showed an original genius in decoration. The products of Ninsei were a type of what is now commonly known as the buff or cream-coloured wares of Awata. This ware, which he made at Omuro, Kioto, is of hard paste, and has a very fine and uniform crackle like the roe of a fish; it is enamelled on a buff ground with floral designs in blue and green tints heightened with gold. This brilliant enamelled faïence, of which the authentic specimens bear his impressed seal, laid the foundation of a new national school of faïence which spread extensively and has been ever since continued. Soon Kioto was filled with kilns, which emulated the products and imitated the style of Ninsei. The authentic old ware of Ninsei, of which I show you a series of specimens, is followed only at a distance by his successors, and most of the modern Awata ware utterly fails in glaze, crackle, and perfection of enamels, even to resemble the works of the master whom it imitates. His most famous follower was Kinko-zan, who in the next generation and in the early part of the 18th century, brought to great perfection the Awata ware—a ware resembling that of Ninsei, and enamelled with similar colours, but especially with a deep purple enamel raised in relief. The old work of Kinko-zan may be recognised by the fineness and uniformity of the crackle, of the clearness and finish of the enamel designs. The modern Awata imitations of Ninsei and Kinko-zan are thin, cold, and dry in glaze, and the enamels are less carefully and perfectly applied. I am sorry to see the names of Kinko-zan and of Ninsei impressed and painted in gold on many obviously inferior modern specimens which have lately come under my notice. This system of forging old names upon worthless modern pieces is much to be deplored, and adds greatly to the difficulties of collection. I have accordingly in this, as in all departments, excluded from my collection any specimens which have not passed through the most rigid examination, and do not answer al the tests of the educated critic.

KENZAN, HIS WORK AND INFLUENCE.

Next to Ninsei in time, but not less in fame or genius, or in the great influence which he exercised on Japanese faïence, was Kenzan, brother of the celebrated Ogata Korin, who lived from 1663 to 1743. He was a painter of the supremely impressionist style, as you will see from examining specimens of his work in any collection of kakemonos. In moments of relaxation he was also a lacquerer, as you have seen. As a potter he was supreme, and introduced into the decoration of pottery a new and highly original style of decoration of surfaces, with free-hand impressionist drawings of birds, flowers, grasses, and delicately suggested landscapes in coloured enamels. His style not only created a new school in the pottery of his country, but still influences in the highest degree all our modern European decorated porcelain. Until the time of Kenzan, this freely sketched floral decoration was unknown on porcelain or china. You will recognise at once the Kenzan style on the series of pieces which I show you, and perhaps your first impression will be to say at once, Yes, but this is in many respects like what we see now on modern china, and there is nothing original about it. That is the observation often made. It is just the same naive tribute to his genius which is sometimes paid by the uneducated visitor to a representation of one of Shakespeare's plays, when he says all this cannot be new, I have heard so many of these lines before. Kenzan's delicately pencilled flowers, lightly touched landscape, his tufts of grass, this view of Fusihama, displayed as through a mist, strike you as old familiar friends in the decoration of porcelain, because the genius of Kenzan gave the cue to all the potters of Japan, and subsequently to all keramic decorators of the world, when they became acquainted with the products of his genius. These are the originals from which our modern school of decoration chiefly spring. I recommend them to your study, and especially this exquisitely chased figure of the mother playing with her child, which, for naturalistic grace and beauty of decoration will probably strike you as being in itself beautiful, and as thoroughly accordant with modern taste as with the Oriental notions of the primitive Japanese. Kenzan was a poet also, and he often wrote his verses with his own hand on his landscapes, as you see in some of these specimens. All his pieces are signed with his bold monogram. I am sorry to say that even that has lately been imitated by an accomplished modern potter, Tanzan, who, however, I believe, had no intention of deceiving when he did so, but intended it as homage to the old master, of which, however, unfair advantage is sometimes taken in passing off the pieces as if they were the original pieces of Kenzan. Kenzan passed a great part of his life at Kioto; later he went to Yedo, where he made pottery of softer paste. His pieces belong to two periods, Kenzan ware of Imado and Kenzan ware of Kioto. The paste of his Kioto ware is often inferior, but its decoration is admirable. There is about the work of Kenzan a certain archaism and a masterly roughness and boldness which sometimes shocks the modern eye. They must be looked at as the products of an impressionist artist of the 17th century, and belonging to an Oriental who preferred a suggestive to an imitative art. They are among the rarest and most precious products of the great school of Japanese pottery, and as such I have set myself the task of collecting as many authentic pieces as possible, and for that purpose have secured for this collection a considerable number of authentic pieces, such as can never again be brought together. They constitute a part of the collection, in which I take much pride and pleasure.

THE OLD SATSUMA FAIENCE.

Finally, I must speak to you of Satsuma faïence of Japan, and it is that of which some bastard varieties produced in modern times, have a most extended popularity. Undoubtedly the old Satsuma ware, of a particular period, viz., the end of the last century, was the most aristocratic, the most delicately decorated, and the most perfect, in its technical qualities, of any faïence which Japan has produced, and it has an artistic as well as historic interest. But there are many fallacies current concerning Satsuma ware and the hard facts do not at all harmonise with the ordinary popular opinion. The beginnings of the Satsuma factory date back to 1600, when the Daimio Shimazu Yoshihiro, on his return in 1600 from the Korea, brought back some Korean potters and established them at Satsuma. The ware of this period, however, was of a quite archaic character, and chiefly in a grey glaze on hard pipe clay base. I show you an authentic specimen of it with characteristically simple archaic decoration scratched into the base beneath a grey glaze. It has a great historic interest from its rarity and its place in the history of the Satsuma factory, but I do not expect you to admire its inartistic character. There is a tradition firmly rooted, and which I believe to be well founded, that in 1670 coloured enamelled faïence of a more decorative character was produced in small quantities at the private factory of the prince by Tangen, the pupil of the famous Tanyu, who was sent for to Satsuma to decorate some pieces for the prince. This Satsuma-Tangen ware is especially described by the late Captain Brinkley as being among the rarest treasures of the collections of Japan. No other specimen is known in Europe than this flat yellow bottle which I present to your notice. You will see that, unlike any other specimens of Satsuma ware, it is decorated with figures painted in brown and of the Kano school. The enamel decoration at the upper and lower edge and the character of the paste are quite decisive of its origin. But for a careful examination of the paste and of this enamel border, you would recognise it as of Satsuma ware. This, then, must be considered a unique specimen of the Satsuma Tangen ware, which is of the utmost rarity even in Japan. In the 17th century the kilns of Satsuma were little employed and lost their fame; but about the year 1700 the Prince Yeio restored the fabric by employing Kin and Kuwabara, who created the peculiar hard close-grained ware, with the cream coloured finely crackled glaze, and with a paste dense as ivory; with limited decoration in enamalled diaper and conventional flowers and dragons. This is the type which established the unrivalled reputation of Satsuma for the specialty of its faïence; but it was only about the year 1765, or, as some people say, 1785, that this perfected and characteristic variety of Satsuma ware which we know, and of which I show you some magnificent specimens, was produced under the patronage of Shimadsu Nawonobu by an artist named Honda Yenosuke, and it is to this period that belongs the finest ware. This old Satsuma was never in the market, and was unprocurable in Europe until quite lately. It was made only for the prince, for his friends and for gifts to the Court. You may judge of the perfection of its close-grained ivory base, of its delicate crackle, of its hard, sharp modelling, of its perfectly brilliant and delicately coloured enamels, of its gilding, which is like jeweller's work, by the specimens which I show you. If you compare it with the masses of modern Satsuma ware, decorated at Kioto now-a-days for the European market with designs of saints, deities, warriors, highly gilded and often surcharged with ornament, you will be able to distinguish between the rare original products of the princely factory and the masses of modern Kioto, so-called Satsuma, with which the market is now flooded. The figure which I show you (a portrait) was a present at the beginning of this century from the Prince of Satsuma to a great dignitary, from whose collection it comes direct to me. This Koro is, both in incised and in perfection of work, an example of unrivalled importance. You have here also specimens so rare that you will hardly recognise them as Satsuma until you examine the paste of this old monochrome greenish-black Satsuma vase and of the *flambe* Satsuma vase. In this screen, the tiger among the bamboos, and this pœony, you will recognise other examples of old varieties of Satsuma no longer produced, but of great rarity and relative perfection. I would recommend you to study these specimens of genuine old Satsuma to note the extreme solidity of the ware, its restrained and graceful decoration, its ivory-like surface, the sharp cutting hardness of its edges, the perfection of its gilding, and the unfailing accuracy of outline of its enamels: their brilliant and yet delicate colour, because there is nothing as to which so many delusions prevail as to what is called old Satsuma. There are few collections, however small, which do not boast something which is called old Satsuma. From my experience of many great collections, I am compelled to say that I do not know of a dozen specimens in this country; and, indeed, while there is nothing so abundant as highly-decorated modern pieces of Satsuma, there is nothing so rare as fine and authentic specimens of the real old ware. There are no marks by which Satsuma may be known except the study of its paste, its crackle, its enamels, and its gilding, and to distinguish between the new and the old would seem, from the numerous deceptions from which I have known both dealers and collectors to suffer, to be one of the most difficult arts for the Japanese collector to acquire. I believe, however, if you will for a half-an-hour carefully compare these authentic old specimens with any modern specimens which you choose to put alongside of them, you will be able to master that art; and to help comparison here is a vessel in old Satsuma ware of very fine quality. When I say old Satsuma ware, I mean as old as characteristically decorative Satsuma was—that is to say, Satsuma ware of the end of the last century or the beginning of the present century. Notice the cover; it has been made probably about twenty or thirty years ago, also at Satsuma, probably to replace one which was broken, and carefully to imitate the old ware: you have only to look at the blackness of the reds, at the imperfections and relative impurity of the gold employed in the gilding, and at the relative feebleness and want of edge of the enamels, and at the dryness of the glaze and irregularity of the crackle, to see the difference between a fine old and rare piece from the kiln of the Prince of Satsuma, and of the careful modern imitation.

Now, gentlemen, I must take leave of you, while thanking you most heartily for the unwearied attention and enthusiastic kindness with which you have received my efforts to unfold to you the history of some of these masterpieces of past arts among the most remarkable of Oriental nations. They belong to a chapter in the history of the world which has been closed for ever. The Japanese have entered on a new phase. They have become scientific and commercial. Science and commerce bring with them so many blessings, that we must be content to see pass away, with a sigh of pleasing regret, those primitive virtues and that original phase of art which can only be found among a people whose inspirations are drawn direct from Nature, and are unadulterated by European admixture. Japanese art is quaint, original, poetic, fantastic. It has limitations and defects obvious to the casual eye, and more likely perhaps to strike the uneducated observer than its beauties and profound meaning. We have endeavoured to study the art products of old Japan sympathetically and with understanding, and it has been to me a source of pleasure which I cannot easily forget, to find that I have been able to interest audiences so crowded, so indulgent, and so sympathetic, in works of art which have for me an enduring attraction, and which seem to me to deserve one of the highest places in the history of art.

I heartily thank you for the indulgence which you have shown to me, when entering on necessarily dry details; and for the kindly enthusiasm with which you have encouraged me in my rather difficult task.

CANTOR LECTURES.

ANIMAL MECHANICS.

By B. W. Richardson, M.A., M.D., F.R.S.

Lecture III.—Delivered May 17th, 1886.

Methods of Natural Construction.

(Abstract.)

Natural constructions were compared with others produced by man. The jointing of bone by the suture was compared with the dovetailing of mechanical art; the fabrics woven by Nature with those woven by man; the vibrating drum of natural formation in the tympanum with the drum and vibrating screen of human design; the natural osseous column with the column erected by the architect; the tubular system of the arteries with the tubular arrangements of human invention for the conveyance of water and other fluids; the sacs or pouches in some animals for water carriage, as in the camel, with the water holders of human make; the eye as a camera, and the common camera now in such ordinary use. These were all, practically, the same as means for particular ends; and these having been illustrated, the subject was varied in order to introduce details of methods of construction, with comparisons and distinctions between the works of Nature and man. 1. Nature and man go to the same markets for their primary materials. Neither of them works without proper materials, although Nature is able to work with fewer than man, and man often takes structures, such as cotton, which Nature has prepared for him, and applies them to his mechanical purposes. Man also possesses an advantage in that he can bring together his materials from a distance, while Nature only produces at points where the required materials are at hand and ready for application. 2. Nature as well as man requires for her work certain preliminary conditions for construction besides material—that is to say, constructive forces: proper attractions and repulsions, correct degrees of moisture, of temperature, of pressure, of light. These imperfect or unsuitable, the work in both cases is imperfect or wanting in adaptability. Even Nature's crowning work, the highest order of animal construction, the human body, is rendered imperfect if the required conditions are not duly represented. 3. The mechanical works of Nature, like those of man, wear out, but not precisely in the same way. Some parts, those which are elastic, wear out in a manner extremely similar, but Nature seems to have a more systematic destiny for her work than man has for his contrivances. Nature has five successive stages: one of development, a second of maturity, a third of maintenance, a fourth of decline, and a fifth of dissolution. These stages were traced out, and the theory of Flourens, indicating the period of maturity in animals and the multiplication of that period by five for the period of dissolution, was described—man, who had assigned to him twenty-one years as his period of maturity, having 105 years as his period of dissolution, or completed anatomical age for death, the death taking place, under the fulfilled ordination, from failure at the breathing surface and from a process of anæsthetic sleep. The works of Nature thus grow out of existence, while those of man shake or vibrate out. 4. Natural works as well as human are subject to wear and physical accidents, and both are made to undergo repair, in which work of repair Nature is often most skilful, though (she may require directing), as in the case of a broken bone, where she brings together the broken ends, and for a time supports them by an extra deposit, called by the surgeon the callus, which, when it has served its purpose, becomes reduced or passes away altogether. In treating of the wearing out of natural parts, Dr. Richardson was not in favour of the common idea that every part of the body is renovated and replaced by absolutely new material in a limited number of periods—say of seven years—during life. 5. In her mechanism Nature never traverses laws which man may not. She is not kinder to herself, not less exacting to herself, than to man. She acts in regard to her own mechanism as if she, like man, were obeying a primary power which had provided materials and laid out the conditions. Hence Aristotle had speculated as if in the natural mechanism two powers had been at work, one to give and command, the other to use and carry out by mechanical skill the details of mechanical art. 6. In all the above particulars the works of Nature and of man present much that is in common. When, however, we come to method of work, the difference is as wide as it can be. Nature works from a centre, man works towards a centre; Nature distributes, man concentrates; Nature strikes out or evolves, man brings in and founds or builds. If we could out of the primary elements used by Nature construct a cell that would accrete to itself and give out another cell, the first step of natural construction by evolution would be attained. Without assuming this to be attainable or not, the lecturer passed to a brief description of some recent experiments of his own in micro-electroscopy, from which he explained that by electric decompositions of organic fluids, like blood, he had produced constructions which in many particulars resembled various organic tissues; and concluded with illustrations relating to what he designated "the growth of form" in natural and human combinations.

Lecture IV.—Delivered May 24th, 1886.

MECHANICS OF THE CIRCULATION.

(Abstract.)

The description of the circulating apparatus was commenced from the venous side of the circulation. A drawing, of life size, from Vesalius, was thrown on the screen in order to illustrate the entire venous system as in a transparency. The faithfulness of this work of the great anatomist was exhibited in this figure, and was followed by another in which the main trunks of the veins were indicated as the receiving trunks of what Dr. Richardson designated the true river of life. The circulation of blood, in it primary movement, begins, he contended, in the veins, in a venous current which does not depend in the first instance on the stroke of the heart, but which has its origin in the digestive tract, and which supplies the heart, as from a vast surface of absorption, with fluid, from food and drink, and from the lymph formed in the drainage surface of the body. The great venous channels, the rivers of life, thus supplied, run, guided by the valvular arrangements, into the right side of the heart and form the primary force of the circulation. The rivers charged, the right auricle of the heart needs but a moderate pumping power to deliver the blood it receives to the right ventricle for distribution to the lungs, and, by comparatively easy stroke over the lesser or pulmonic circuit, to the left auricle, and so on to the left ventricle for arterial pulsating circulation. The part which pulsation plays in the arterial system was made matter of comment, in which it was suggested that the pulsating motion is necessary for all secreting, excreting, and nutritive functions, since by it a period of rest from propulsion is secured after each systole, during which period of rest the required changes can be carried out. Quicken the pulsations until the current is exalted into an almost continous course, as in fever, and then with the generation of heat there is reduced secretion, excretion, and nutrition. Reduce the pulsation, so as to leave long periods between each stroke, and then with a reduction of temperature there is obstruction, accumulation, and impaired restoration of function. From this description of the course of the circulation, the lecturer passed to that minute circulation of the blood, in the capillary system, in which the chemical part of the vital actions is carried out. From two of Rudinger's photographic plates of dissected structures he showed the centres of the nerves of organic life, and having indicated how these and their ramifications differ from the centres and nerves of the cerebro-spinal system, he traced the organic nerves through their distribution along the course of the arteries to the capillaries, and explained how, by their controlling influence, the supply of blood to different organs is modified. The influence of emotion, through the organic nervous system, upon the vascular system, and upon the colour of some parts of the body, such as the cheeks, was indicated in the acts of blushing and the paling of the cheeks under excitements from joy, surprise, or fear—an exposition which led to a suggestion by Dr. Richardson, that the absorption of the vibration incident to arterial pulsation is probably effected by and through this nervous arrangement. The picture of the arterial system as a whole, from Vesalius, was thrown on the screen, and the mechanism of the arterial tubes was shown, as in transparency, of life-size. This vast series of tubes from root to minute branch up to the commencement of the capillary tubes is all through life, in waking and in sleeping, in one continued swing of balancing pulsation; and yet in health we are unaware, by any sensation of so strange a fact, and of the part which the central heart, or pump, itself plays in it. There must, therefore, be an absorption of the vibration somewhere, and the lecturer thought it most probable that this was by and through the organic nervous fibres. The vibrations are conducted back to the nervous centres, and transmitted from them to other organic parts to be disposed of in work, physical and mental. So when the heart is beating very strongly, we feel the reflex back into the great ganglionic centres of the stomach in sensations varying from a pleasant glow to spasm or acute pain.

Lecture V.—Delivered May 31st, 1886.

MECHANISM OF THE HEART.

(Abstract.)

The circulation through the heart itself was first noticed, and the provision by which it is secured that the heart shall be fed with blood permanently, as the primary organ of the circulation, and in that sense the organ which requires to be served before any muscle of the body, voluntary or involuntary. In the second part of the lecture Dr. Richardson described the movements of the auricles and the ventricles, the diastoles and systoles, and the valvular actions during each series of movements. In this part he explained that he had seen the heart working under two distinct tensions, which he designated as the high or full vital tension and the low or syncopal tension. Under the high or full tension, the volume of the heart is large and the stroke so powerful as to distend the whole of the arterial trunks; under the low tension, the volume of the heart is reduced to fully half that of the high tension, and, although the motion of the auricles and ventricles is still in correct order as to time and method, the propulsion is so feeble that the arteries are not distended. In this minor condition of action the circulation is sustained, as during syncope and catalepsy, but in a passive or negative state, from which the revival is sometimes all but instantaneous, owing to a sudden return of the heart to its full power. In an experimental observation under anæthesia, the lecturer had witnessed in a lower animal this transition in the work of the heart from the low to the high tension. It was the work of a moment, was attended with phenomena resembling a restoration from temporary death to active life, and was due probably to a restored balance of the nervous supplies by which the heart is naturally maintained in equilibrium of motion.

The observation on the equilibrium of motion led to a description of the nervous supplies of the heart; the propelling from the sympathetic source; the controlling, through the pneumogastric, from the cerebro-spinal source. Here Rudinger's dissections of the cardiac nerves were thrown on the screen. The number of the pulsations of the heart in different animals —in fish, frog, bird, rabbit, cat, dog, sheep, horse—was described, and a few comments made on the remarkable slowness of the heart —40 strokes per minute—in the horse. Then the number of pulsations in man at various periods of life, and at different levels, from the level of the sea up to 4,000 feet above sea level, was brought under review, and was followed by a computation of the average work performed by the heart in a healthy adult man. The work was traced out by the minute, the hour, and the day, and was shown to equal the feat of raising 5 tons 4 cwts. one foot per hour, or 125 tons in twenty-four hours. The excess of this work under alcohol in varying quantities formed a corollary to the history of the work of the heart, Parkes' calculation showing an excess of 24 foot-tons from the imbibition of eight fluid ounces of alcohol. The facts relating to the work of the heart by the weight of work accomplished was supplemented by a new calculation, in which the course of calculation was explained by mileage. Presuming that the blood was thrown out of the heart at each pulsation in the proportion of 69 strokes per minute, and at the assumed force of 9 feet, the mileage of the blood through the body might be taken at 207 yards per minute, 7 miles per hour, 168 miles per day, 61,320 miles per year, or 5,150,880 miles in a lifetime of 84 years. The number of *beats* of the heart in the same long life would reach the grand total of 2,869,776,000.

In the next part of the lecture the sounds of the heart were described and imitated, and the muscular construction, with special reference to the spiral character of the cardiac action, was illustrated on the screen from Pettigrew's series of photographs of dissections of the heart. The effect of the ventricular contraction on the arterial pulses was also illustrated by a series of sphygmographic tracings, showing the natural pulse tracings and the various deviations from the natural under the effects of alcohol, tobacco, opium, and exposure to extreme cold. The resistance produced by cold was illustrated from the tracing of the pulse of Mr. Fleuss after his immersion for an hour in water at 35° Fahrenheit.

[Professor H. S. Hele Shaw's fourth lecture on "Friction" will be printed in next week's *Journal.*]

Miscellaneous.

INTERNATIONAL CONGRESS OF AMERICANISTS AT TURIN.

The Sixth International Congress of Americanists was held recently at Turin, under the patronage of H.M. the King of Italy, who was represented at the inaugural meeting by H.R.H. the Duke of Aosta. The object of this association is, as its name infers, to promote the study of all relating to the history, archæology, &c., of that country previous to its discovery by Columbus. The meetings were held in the Palazzo Carignano, under the presidency of Professor Ariodante Fabretti, Director of the Museum of Antiquities of Turin. Several countries were represented officially, amongst which Spain by the Senator Fabié and Senor Jimenez de la Espada; Belgium by M. Dognée; France by M. Desiré Charnay, the explorer of the ruined cities of Central America; Denmark by Professor Waldemar Schmidt, of the University of Copenhagen; Brazil by his Excellency Lopez Netto, the Brazilian Minister at Rome. Other countries, though not officially, were also represented—the United States, Germany, Portugal, Russia, Egypt, Uraguay, Paraguay, Columbia, the Argentine Republic and Liberia. The majority of the foreign members were French and Spanish; England was not represented at this congress. The subjects to be discussed were divided into four sections, the 1st comprising geography, history, and geology; the 2nd, archæology; the 3rd, anthropology and ethnography, whilst the 4th was devoted to paleography and philology.

The inaugural meeting was held on September 15th, and the Syndic welcomed the foreign visitors to Turin in the name of the Municipality. The President then declared the meeting open in a short address, in which he alluded to the part taken by Italy in the discovery of America, to the fame of the Genoese and Venetians as navigators during the Middle Ages, and of Christopher Columbus, the great Genoese, to whose courage and perseverance the scientific discovery of the New World is due.

Professor Waldemar Schmidt (who was the chief organiser of the last congress which was held at Copenhagen, in 1883), said that if the Italians claimed the discovery of America for their fellow-countryman Columbus, within historic times, its discovery in pre-historic times was no less due to his (the Danes), and alluded to the voyages of the early Scandinavian navigators, and the probable emigration of the Celtic tribes to America.

Senor Fabiè, the Spanish delegate, observed that if the Italians claim the discovery of America for their countrymen, it was to Spanish enterprise, and to a Spanish king that the little expedition under Columbus was fitted out, and the vessels were manned by Spanish seamen.

M. Desiré Charnay deplored the indifference towards the study of ancient American civilisation, and especially with regard to ancient Mexican art, which is ignored by the public in general, whilst the classic art of the East alone is considered as worthy of study.

A "conversazione" was held in the rooms of the Geographical Society of Turin. The programme of the second day's meeting related chiefly to the history and geography of America, and particularly to the voyage of the Venetians, the brothers Leno, to the Northern Ocean towards the end of the 14th century. Two papers were read, one by the General Secretary, Professor Cora, on this subject, and another by M. Beauvois. With regard to the voyage of these Venetian sailors, there can be no doubt that they did reach the shores of Greenland, and the chart published at Venice, illustrating their journey, is, without doubt, of great value, as the position of the Northern Seas are correctly indicated.

To Christopher Columbus, however, is due the honour of having scientifically discovered the new continent. Other navigators previous to him, as the Scandinavians, Basques, Irish, &c., may by some strange chance have reached the shores of America, but no navigator previous to Columbus had deliberately set sail from a European port with the fixed purpose of seeking Eastern shores by steering West, or, in the words of Herrera, *buscando el levante per el poniente*—"a thing more divine than human"—as was said at the Court of King Henry VII., when the first tidings of the discovery of Columbus reached England.

The third meeting was held on the 17th, under the presidency of Senor Fabié, who, in the name of the Academy of Madrid, presented a large collection of important works relating to American archæology and antiquities. Several papers were read by Professor Cora, amongst which a monograph on the origin of the name "America," on "Danish Explorations in Greenland," by Professor Schmidt. Professor Vincenzo Grossi, the Orientalist, contributed a memoir on the literature and *folk-lore* of the primitive populations of America. M. Desiré Charnay read a paper on "The Pyramids of Izamal and the Ruins of the Temple of Kab-ul," which was followed by a memoir by Professor Grossi on "The Pyramids of the Old and New Worlds." Among the other papers may be mentioned on "The Kjökkenmöddings of America," by Senor Gimenez de la Espada, which gave rise to a discussion, in which Dr. Pigorini, director of the Prehistoric Museum of Rome, and Prof. Schmidt took part. M. de Baye read a paper on "An Idol recently discovered in Guatemala."

At the last day's meeting it was decided that the next congress should be held at Berlin. Amongst the various papers read was one by Professor Grossi on "The Mummies of the Old and of the New Worlds;" a note by M. De Monclar on "A trepanned skull found in the basin of the Amazon;" Professor Schmidt read a memoir by M. H. Rink on "The Eskimo Tribes of the East and of the West;" Professor Cora read a paper on "The Ancient Maja Language;" Herr E. Seller, of the Royal Ethnological Museum of Berlin, read a paper on "The Ancient Mexican Picture Writing, and especially the Codex Borgia and the Codex Vaticanus B;" Senor Gimenez de la Espada contributed two memoirs on "The Guippos," the other on "The Caribe Dialect."

The members of the Congress left for Genoa, which claims to be the birth-place of Christopher Columbus.

SWEET POTATO IN THE WEST INDIES.

The sweet potato *(Batatas edulis)* is, according to the *European Mail*, the main food crop at Barbadoes, where the yam is little known, whereas at Jamaica the converse is the case, the yam (*Dioscorea*) being very largely grown all through the interior hills, while the cultivation of the sweet potato is confined to a few places in the lowlands. The following information was obtained by the editor of the *European Mail* from Mr. D. Morris, late Director of the Public Gardens, Jamaica, and now of the Royal Gardens, Kew. Since the large emigration of negroes to the Isthmus of Panama there has arisen a considerable trade in yams between Jamaica and Colon, to the manifest advantage, in present cash returns, of the former country. Unfortunately, the cultivation of yams entails the cutting down of forest year by year, as good yams seldom do well, in the manner cultivated at Jamaica, except by the "rotation of land"—a peculiar negro mode of interpreting the European idea of "rotation of crops." Hence it is not very desirable, from a general economic point of view, to extend or encourage the cultivation of yams. With the sweet potato, however, it is different. This can be grown without the sacrifice year by year of valuable virgin forest, and it is, in many respects, a crop well adapted to all the lowlands, not only of Jamaica, but also of the West Indies generally.

Besides being utilised directly for food purposes, it would appear that a new demand is likely to arise for the tubers of the sweet potato in connection with the production of alcohol. The first notice of the sweet potato being utilised in this manner appeared in a report to the Foreign Office given by Consul Hertslet on the trade and commerce of the Azores for the year 1884.

Owing to a variety of causes, it appears that cultivators at St. Michael's and other islands of the Azores, who had hitherto looked upon oranges as their staple production, were so disheartened by low prices and the diminished crops yielded by their trees, that they resolved to clear their land of everything and plant it afresh with sweet potatoes. The whole of the crop thus raised was used in the preparation of alcohol. During the year 1884, 1,826 pipes of alcohol, of the value of £40,518, made from sweet potatoes, were exported from the Azores to Lisbon, and subsequently, the trade assumed still larger proportions.

Encouraged by the success of the enterprise at the Azores, it appears that a French chemist, Monsieur A. Ralu, having much experience in chemistry, as connected with distillation, and possessing extensive relations with the West Indies (Martinique), has taken out patents:—1. For utilising as a commercial and industrial substance sweet potatoes and yams, by means of desiccation and conversion into flour; and, 2, for distilling alcohol from the above flour.

In relation to the ordinary or Irish potatoes, white beetroot, and maize flour, sweet potatoes possess an alcoholic richness of 15·50 per cent., as compared with 8 and 9 per cent. of the Irish potato, and 4 and 5 per cent. in the beetroot. The value of raw sweet potato for distillation, and its superiority, both as to quantity and quality, over other substances, has been for some time known and recognised. The difficulty has been in extracting the alcohol on the spot; added to this, there is the danger attending its exportation, for it is impossible to prevent leakage, and the vapour of alcohol at 95° Fahr. in hot climates is said to be inflammable. Alcohol, therefore, is assumed to be a dangerous cargo. As alcohol cannot, it is supposed, be made on the spot and exported to Europe, Mons. Ralu's patents aim at the preparation of sweet potato flour in the West Indies, from which afterwards the alcohol may be distilled and utilised in Europe.

As already noted, one establishment for distilling alcohol from raw sweet potato exists at the Azores, and since it began work it is said to have doubled its plant, and all the alcohol it produces is sold in advance at Lisbon, where it is used for the fortification of wines. M. Ralu says:—"The alcohol of which we have specimens is superior in quality to the best marks of France. The distillery obtains 12 per cent. (*i.e.*, 12 litres of alcohol at 100° per 100 kilog. of sweet potato) of alcohol. We have experimented with the sweet potato of Algeria. They give 13 4·10 litres of alcohol per 100 kilog. The sweet potato of Martinique and Brazil have given 15 litres. There is here, therefore, a very rich material for distillation. Ordinary potatoes yield only 3 litres of alcohol per 100 kilog."

The objects sought by Mr. Ralu's patent involve the extensive cultivation of the sweet potato in the West Indian Islands, its desiccation by means of fruit driers, its reduction into a meal, and its export to Europe, where an almost unlimited demand exists for sweet potato meal for distilling purposes. The alcoholic richness of the sweet potato is shown by the following Table:—

	Francs.	Litres.
Wheat..............	19·75 to 21·50	28 to 30
Rye................	15·50 to 16·25	22 to 23
Barley.............	17·75 to 20·00	24 to 25
Oats...............	17·25 to 19·50	20 to 21
Buckwheat..........	16·00 to 17·00	24 to 24
Maize..............	14·00 to 14·50	28 to 30
Rice...............	18·00 to 19·00	32 to 33
Sweet potato flour....	14·00 to 15·00	38 to 39

Maize, it will be seen, is the only cereal which is as cheap as the potato flour, but it requires 324 kilog. (714 lbs.) of maize to make one hectolitre (22 gallons) of pure alcohol, whilst it requires only 235 kilog. (519 lbs.) of the flour to make the same amount of alcohol. There is a great saving of time and combustibles when distilling from the flour, as compared with the maize. Alcohol from maize costs 10 francs per hectolitre more to make, and when made sells at from 8 to 10 francs less than the alcohol made from the sweet potato flour.

The sweet potato at present cultivated in Jamaica is mostly intermingled with other plants in the provision grounds of the negroes. Hardly any is cultivated by Europeans. No definite area is returned as exclusively devoted to this cultivation, and no returns of yield per acre are available from authentic sources. A negro in the same ground will have yam (Dioscorea), corn (maize), sugar cane, and possibly, also, two or three other plants, such as bananas, plantains, cocos (Colocasia).

Sweet potatoes thrive best in rich friable soil free from clay.

At the foot of the Liguanea hills, and, indeed, in most localities with the soil indicated above, they are found to thrive. They are easily propagated by slips or portions of the stem planted in rows or in hills. The roots come to maturity in three or four months, and the cultivation is continued by covering up the stems when digging up the more perfect roots for use. The crop comes in practically all the year round. There is no regular season for it, and hence it can be best harvested by examining the state of the roots, and taking out those that are found perfectly ripe. The crop may be gathered at least three or four times in the year, but as to the amount or value of each cropping no data are immediately available.

If the cultivation were undertaken by sugar planters, and large areas were planted with sweet potatoes, there is little doubt that in Jamaica they might be grown as advantageously and as successfully as anywhere.

Correspondence.

EAST AFRICAN DRUGS.

In an article on the above in your issue of October 15th, p. 1217, mention is made of a creeping plant "with bean-like, hairy S-shaped pods, having severe stinging powers; it is about four inches long, of yellowish brown colour, and is called *upupu.*" From this description, I think it is doubtless identical with the *Mucuna pruriens*, D.C., which is found in the locality mentioned, and is well known on account of the irritant hair which envelop the pod. In the same article reference is also made "to the *muavi*, or poisonous decoction of the bark of a tree, employed in the trial by ordeal of the natives of the Nyassa and Zambesi valley." This is evidently the *Erythrophlœum guineense*, Don., or sassy bark of Sierra Leone, which is known to be used as an ordeal in Nyassa. The bark is powerfully poisonous, and is administered by native tribes in widely-remote regions of Tropical Africa as an ordeal.

JOHN M. HILLIER.

Museum, Royal Gardens, Kew.

Notes on Books.

ENGLISH GLEES AND PART SONGS: An Inquiry into their Historical Development. By William Alex. Barrett, Mus.Bac., Oxon. London: Longmans, Green, and Co. 1886. Sm. 8vo.

This book has grown out of a course of lectures delivered by Mr. Barrett at the City of London College, under the auspices of the "Society for the Extension of University Teaching." After dealing with the origin of vocal harmony from the early times to the fifteenth century, the author proceeds to his particular subject, and traces the history of the glee and of the madrigal. He writes:—"From the time of Henry III., to whose reign belongs the early piece of music, 'Sumer is icumen in,' to the days of Queen Elizabeth, the round, catch, or canon was a favourite form of musical diversion." The earliest publication of madrigals in England was the "Musica Transalpina," published by N. Yonge, in 1588. This was followed by the collections of Thomas Watson, John Wilbye, Thomas Weelkes, Thomas Morley, and others. Troublous times came for musicians when the civil wars broke out, and it was not until after the Restoration that they regained the position they had lost. Then musical clubs and meetings became the vogue. The earliest catches of Purcell were printed in a new edition of "Catch that Catch Can," in 1685. Mr. Barrett says, "The genius of Purcell embraced with equal felicity every species of composition," and adds, "the study of the works of Henry Purcell would be found to be among the most profitable preparations for a complete and lasting foundation that a young musician could enter upon." With the opening of the eighteenth century, appear the names of Dr. William Croft, John Blow, and Dr. Maurice Greene. A chapter is devoted to Dr. Arne, and then follow, among many lesser lights, Samuel Webbe, John Stafford Smith, Reginald Spofforth, Dr. Callcott, Richard J. S. Stevens, Dr. Horsley, Samuel Wesley the elder, Samuel Arnold, and Thomas Attwood. With the nineteenth century arose Henry Rowley Bishop, who was born in 1785, and commenced his musical career with a piece performed in 1804. The last chapter contains a notice of the glee in the nineteenth century, with mention of Sir John Goss, Pearsall, Smart, Hatton, and Macfarren. The author, in concluding, writes that the statement of the deficiency of musical capacity in England should be strenuously opposed with counter statements in vindication of facts.

PRACTICAL MERCANTILE CORRESPONDENCE. English-French and French-English. By Chr. Vogel. London: Whitaker and Co. 2 vols., 8vo.

These volumes contain a collection of forms for business letters arranged under twenty headings, and a "Dictionary of Commercial Terms." Each volume is a complement of the other, the same letters being given in each, in English in the one, and in French in the other.

A POCKET CYCLOPÆDIA OF USEFUL KNOWLEDGE ON A THOUSAND SUBJECTS. By Henry Grey. London: Griffith, Farren, Okeden, and Welsh, 1886.

This little book contains a short account of such points of useful information as may be required by the general reader. It is illustrated with a series of coloured diagrams.

Obituary.

GEORGE CLOWES.—By the death on the 3rd inst., of Mr. George Clowes, the Society of Arts has lost a member of thirty-five years' standing, he having joined the Society in 1851. He was born in 1814, and was the last surviving son of William Clowes, the founder of the house of William Clowes and Sons, the well-known printers. He was educated at Tooting, and at University College, London. It was originally intended that he should become a barrister, but from the increasing responsibilities of his father's printing-office he was induced to adopt that business instead of the legal profession. He married, in 1837, the eldest daughter of Charles Knight, in whose schemes for the diffusion of knowledge he personally took the greatest interest, and he was invariably consulted by his father-in-law in all his large undertakings. He was for many years auditor to the Guild of Literature, a scheme started by the late Lord Lytton, and he assisted the Bar Committee for Law Reporting in the business portion of their undertaking. Mr. Clowes took a prominent part in the production of the catalogues and other official publications of the 1851 Exhibition. He took an active part in the printing business till within the last year.

PROFESSOR GUTHRIE, F.R.S.—Dr. Frederick Guthrie, who died on October 21st, was born at Bayswater, in October, 1833, and was educated at University College, London. At the age of nineteen he graduated B.A. of the University of London, taking honours in animal physiology. In 1854, he went to Heidelberg, and afterwards to Marburg, continuing the chemical studies which he had commenced at University College under Thomas Graham, Williamson, and Henry Watts. In 1856, he was acting as assistant to Dr. Frankland at Owens College, Manchester. Three years after he was assistant to Dr. (now Sir Lyon) Playfair, then Professor of Chemistry at Edinburgh. He was appointed Professor of Chemistry and Physics at the Royal College of Mauritius, in 1861, and in 1867 he returned to England. He contributed numerous papers to scientific societies and journals. From 1855 to about 1864 these were chiefly on chemical subjects, and from 1864, downwards, chiefly on physical subjects. In 1869, he was appointed Lecturer in Experimental Physics at the Royal School of Mines, a post which, with modified title and extended duties, he held until his death. He subsequently proposed the formation of the Physical Society, the meetings of which commenced in 1874. Dr. Guthrie was elected a Fellow of the Royal Society in 1873, and a member of the Society of Arts in the present year. In February and March last, he delivered a course of Cantor Lectures before the Society, his subject being "Science Teaching."

General Notes.

EDINBURGH EXHIBITION.—The Edinburgh International Exhibition closed on Saturday, October 30th. The total number of visitors to the Exhibition was 2,769,632, or an average per day of 19,233, per week of 115,401, per month of 461,605.

THE LIBRARY.

The following works have been added to the Library since the last announcement :—

Abel and Imray.—Patents, Designs, and Trade Marks. British and Foreign. (London, 1886.) Presented by Oliver Imray.

Barrett, William Alexander, Mus. Bac.—English Glees and Part Songs. (London : Longmans, Green, and Co., 1886.) Presented by the Publishers.

Bartholomeusz, Oliver.—Minicoy and its People. (London: 1885.) Presented by Sir James N. Douglass.

Benson, Charles.—Records of the Saidápet Experimental Farm. (Madras, 1885.)

Berly, J. A.—Universal Electrical Directory for 1886. (London : William Dawson and Sons, 1886.) Presented by the Publishers.

Commissioners of Patents for Inventions, Reports 1852-83. Presented by H. Reader Lack.

Grant, Robert, F.R.S.—History of Physical Astronomy. (London : Henry G. Bohn, 1852.) Purchased.

Grey, Henry.—A Pocket Encyclopædia of Useful Knowledge. (London : Griffith, Farren, and Co., 1886.) Presented by the Publishers.

Hambleton, G. W.—What is Consumption ? (London : J. & A. Churchill, 1886.) Presented by the Author.

Jago, William.—The Chemistry of Wheat, Flour, and Bread, and Technology of Breadmaking. (Brighton : William Jago, 1886.) Presented by the Author.

Lock, C. G. Warnford.—Workshop Receipts. (Third Series.) London: C. and F. N. Spon, 1884.) Presented by the Publishers.

London (Illustrated) : a complete Guide to the Places of Amusement, &c. (London, 1885, J. P. Segg and Co.)

Melbourne International Exhibition, 1880-1, Official Record. (Melbourne : Mason, Firth, and M'Cutcheon, 1882.) Presented by Edmund Johnson.

Memorial of Alexander Lyman Holley, C.E., LL.D. (New York : American Institute of Mining Engineers, 1884.) Presented by William Whitaker.

Miller, Fred.—Pottery Painting. (London : Wyman and Sons.) Presented by the Publishers.

Muspratt, Dr. Sheridan.—Chemistry ; Theoretical, Practical, and Analytical, as applied and relating to the Arts and Manufactures. 2 vols. (Glasgow : William Mackenzie.) Purchased.

Notizblatt des Vereins für Erdkunde zu Darmstadt und des mittelrheinschen geologischen Vereins. Herausgegeben von R. Lepsius. (Darmstadt, 1884.) Presented by Carl A. Thimm.

Parnell, Edward A., F.C.S.—The Life and Labours of John Mercer, F.R.S. (London : Longmans, Green and Co., 1886.) Presented by the Publishers.

Peter, Richard, and Otho Bathurst Peter.—The Histories of Launceston and Dunheved. (Plymouth : W. Brendon and Son, 1885.) Presented by O. B. Peter.

Philipson, John.—The Technicalities of the Art of Coach-body-making. (London: John Kemp and Co., 1885.) Presented by the Author.

Plasse, L'Abbé.—Le Clergé Français réfugié en Angleterre. 2 vols. (Paris : Société Générale de Librarie Catholique, 1886.) Presented by the Author.

Post-Office Telegraphs. Connections of Telegraph Apparatus and Circuits. (General Post-Office, 1886.) Presented by the Secretary of the General Post-Office.

Raffles, Lady.—Memoir of the Life and Public Services of Sir Thomas Stamford Raffles, F.R.S. (London: John Murray, 1830.) Purchased.

Report on Lighthouse Illuminants. Part II. (London, 1885.) Presented by Sir James N. Douglass.

Rockstro, W. S.—A General History of Music. (London : Sampson Low and Co., 1886.) Presented by the Author.

Rogers, James E. Thorold, M.P.—Six Centuries of Work and Wages. 2 vols. (London: W. Swan Sonnenschein and Co., 1884.) Purchased.

Schellen, Dr. H.—Spectrum Analysis in its application to Terrestrial Substances, edited, with notes, by Capt. W. de W. Abney, R.E., F.R.S. (London: Longmans, Green, and Co.) Presented by the Publishers.

Stone, T. W.—Simple Hydraulic Formulæ. (London : E. and F. N. Spon, 1881.) Presented by the Author.

The Hotels of Europe. (London : J. P. Segg and Co.) Presented by the Publishers.

The Theory and Practice of Hydro-Mechanics. (London, 1885.) Presented by the Institution of Civil Engineers.

Vogel, Chr., Ph.D.—English-French and French-English Practical Mercantile Correspondence. 2 vols. (London : Whittaker and Co.) Presented by the Publishers.

Wanklyn, J. Alfred.—The Gas Engineer's Chemical Manual. (London : Scientific Publishing Co., Limited, 1886.) Presented by the Author.

Weavers' Company, Facsimile of the Ancient Book of the. (London.) Presented by T. O. Hutton.

Journal of the Society of Arts.

No. 1,773. Vol. XXXIV.

FRIDAY, NOVEMBER 12, 1886.

All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

NOTICES.

ARRANGEMENTS FOR THE SESSION.

The First Meeting of the One Hundred and Thirty-third Session of the Society will be held on Wednesday evening, the 17th November, when the Opening Address will be delivered by Captain Douglas Galton, C.B., D.C.L., LL.D., F.R.S., Chairman of the Council. Previous to Christmas there will be four Ordinary Meetings, in addition to the Opening Meeting. The following arrangements have been made:—

November 24.—"Purification of Water by Agitation with Iron and by Sand Filtration." By William Anderson, M.Inst.C.E.

December 1.—Adjourned Discussion on the paper read by Dr. C. Meymott Tidy, on "Sewage Disposal." (Read April 14, 1886.)

December 8.—"Glow Lamps, their Use and Manufacture." By Major-General C. E. Webber, R.E., C.B.

December 15.—"Cameo Cutting as an Occupation." By J. B. Marsh.

Papers for which no dates have, as yet, been fixed:—

"Development of the Mercurial Air-pump." By Prof. Silvanus P. Thompson, D.Sc.

"Photographic Lenses." By J. Traill Taylor.

"Machinery and Appliances used on the Stage." By Percy Fitzgerald.

"Recent Advances in Sewing Machinery." By John W. Urquhart.

"Textile Fibres in the Colonial and Indian Exhibition." By C. F. Cross.

"Irish Industries." By Rev. Canon Bagot.

"Adulteration of Beer." By A. Gordon Salomon.

"Miners' Safety Lamps." By Edward H. Liveing.

Foreign and Colonial Section.

The meetings of this Section will take place on the following Tuesday evenings at Eight o'clock:—

January 25; February 15; March 1, 29; April 19; May 17.

Indian Section.

The meetings of this Section will take place on the following Friday evenings, at Eight o'clock:—

January 21; February 25; March 11; April 1, 29; May 27.

Cantor Lectures.

The First Course will be on "Principles and Practice of Ornamental Design." By Lewis Foreman Day. Four Lectures.

November 29; December 6, 13, 20.

The Second Course will be on the "Diseases of Plants, with special reference to Agriculture and Forestry." By T. L. W. Thudichum, M.D. Three Lectures.

January 24, 31; February 7.

The Third Course will be on "Building Materials." By W. Y. Dent, F.C.S., F.I.C. Four Lectures.

February 14, 21, 28; March 7.

The Fourth Course will be on "Testing Materials of Construction, especially Iron and Steel." By Prof. W. C. Unwin, F.R.S. Three Lectures.

March 21, 28; April 4.

The Fifth and Concluding Course will be on "The Structure of Textile Fibres." By Dr. Frederick H. Bowman, F.L.S., F.G.S. Five Lectures.

April 25; May 2, 9, 16, 23.

Juvenile Lectures.

Two Juvenile Lectures on "Soap Bubbles," by Prof. A. W. Reinold, F.R.S., will be given on Wednesday evenings, January 5th and 12th, 1887, at Seven o'clock. Special tickets will be issued for these lectures.

Proceedings of the Society.

CANTOR LECTURES.

FRICTION.

By Professor H. S. Hele Shaw.

Lecture IV.—Delivered February 8th, 1886.

The Methods of Reducing the Resistance of Friction.

Extensive and numerous as are the useful applications of friction, and indeed absolutely necessary to our very existence, we have only to remember that no motion of material things can take place without causing friction, and that all friction not directly useful is directly prejudicial, and therefore represents a waste of power, to realise that the question of its reduction may be almost as important and wide as that of its utilisation.

The earliest device employed to reduce the resistance of friction probably resulted from the discovery that it was easier to roll than drag those bodies which otherwise were difficult to move. The next step would be made when it was found that the more closely a body approached the circle in section the easier it was to roll, and that heavy bodies which could not, from the nature of their shape, be themselves rolled along, might be made to move more easily when placed upon rollers. The body itself, under these circumstances, moves faster than the rollers beneath, and we find that Vitruvius attributes to Ctesiphon the invention of large hollow rollers, within which the body itself was placed, a device employed long afterwards in our own times to launch the Cleopatra needle.

Long before the invention of Ctesibius an important modification in the mode of employing the roller had no doubt taken place. This modification consisted in transferring the point of support from the upper surface of the roller to its axis in such a manner as to entirely change the nature of the contrivance. The efficiency of the simple roller had been due to the fact that motion was imparted by means of what I have in the previous lecture called "statical contact." The modification in question, which was rendered necessary in order to connect the roller with the body to be moved, by means of what really corresponded to the frame of an ordinary vehicle, involved a certain amount of "sliding contact." But although sliding contact was thus employed, not only was its extent considerably reduced by the device of the wheel, but the progress which had been made in mechanical arts enabled the surfaces between which this sliding took place to be selected and prepared, so that the resistance of friction was as small as possible.

References to the use of wheels frequently occur in the earliest books; there are many such in the Scriptures, and in Assyrian, Egyptian, and Chinese writings. Reuleaux quotes from the earliest Indian literature of the Vedas, 1700 years before Christ, in which mention is made of wheels in such a way as to show that they must even then have been of great antiquity. In Homer the heroes ride to battle in chariots; and my colleague, Professor Rendall, tells me that in archaic Greek writings the three distinct stages of the growth of the wheel can be traced, from the solid disc to the rude wheel built up of planks with its rough axle, such as may still be seen in various parts of the world at the present day, culminating in the elaborate arrangement of spokes and tyre, the construction of which forms the subject of such an elaborate description as to prove that the wheel had, even in the early days of Greece, been brought to a state of great perfection.

Now, in the wheel we have two distinct principles, by the application of which the resistance of friction is reduced, these being—

1. The substitution, as far as possible, of statical for sliding contact.

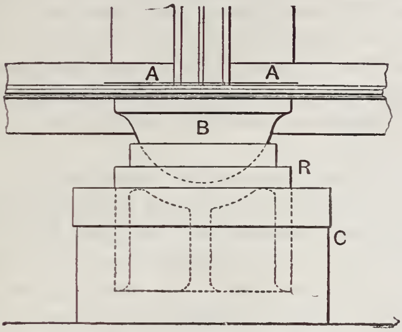
2. The preparation and choice of suitable materials of contact.

This is so, not only in the wheel as applied to purposes of locomotion, but in its countless applications in the arts, from the fly-wheel of the largest engines to the scape-wheel of the smallest watch. Not only is this so where the wheel is employed, but in all cases where the friction of moving parts has to be reduced. Thus we see the same two principles employed in the most delicate balance, where a keen knife edge of the finest steel rests upon an agate bearing, as well as in the massive machine for testing the strength of metals, where a force of 300 tons has to be sustained by a knife edge which, though of increased proportions, acts in a similar way to that of the chemical balance.

These are the two principles in the applications of which heavy structures are made to rotate easily by being placed upon a "pivot."

The annexed figure represents the pivot of the swing bridge over one portion of the floating harbour at Bristol. When the bridge, A A, is required to be turned, the hydraulic ram, R, working in the cylinder, C, is raised, and the weight of the bridge, which usually rests upon other supports, is thus brought upon the pivot. The actual pivot is the steel hemisphere, B, which turns in a socket made in the top of the ram R (which ram does not itself turn). With olive oil as a lubricant, the bridge weighing about 150 tons is easily and rapidly made to rotate.

Fig. 60.



Pivot for Swing Bridge.

But in a variety of more homely examples we see these principles employed; thus in the hinge of every door or cupboard we have a simple but beautiful contrivance by which the sliding contact is reduced to a minimum, the most suitable surfaces being at the same time used where such contact is unavoidable.

In this way, examples might be multiplied indefinitely, and we should find that in all attempts to reduce the friction of solid bodies, and in all contrivances for doing so, either one or both of these two principles are universally employed; and I shall, therefore, deal with the subject of this lecture under two heads, corresponding to methods depending upon their respective application.

It is well to remember that, in all cases, the reduction of the reaction between the surfaces tends to reduce the friction between them, and this reduction of pressure is naturally ensured as far as possible. Thus the pressure on the pivot of a Fourneyron turbine is diminished by the employment of a shield or plate, suspended by a hollow cast-iron tube enclosing the vertical shaft, so that the full weight of water does not act upon the revolving turbine. Again, the slide valve of a steam-engine is often partially "balanced" by means of a ring which is fixed upon its back, the interior of which, communicating with the condenser or with the external air, prevents the pressure of steam acting over the whole valve area, and thus obviates a large portion of the waste in friction which would otherwise occur. The reduction of the weight, or whatever may be the cause of the pressure which causes surface reaction, is, however, such an obvious step, that I need say no more about it.

Before proceeding to consider in detail the mechanical contrivances for reducing the friction of solid bodies, I may point out that the reduction of fluid friction does not need special consideration in this lecture. It is, of course, highly important to bear in mind the facts and laws, concerning fluid friction, which have already been set forth in the second lecture, in order to ensure the minimum resistance in such cases as the flow of water through pipes or the motion of a vessel through the water. As a rule, however, no special devices or mechanical contrivances are employed to reduce liquid friction, which is in fact relatively so small compared with that of solid bodies as to be applied, as we have seen, under the form of lubricants, between surfaces of the latter to reduce their sliding friction. In the case of gases the friction is still less, and is neglected to an extent which may not always be expedient. Thus M. Ricour, chief engineer of the rolling stock on the French railways, gives an account of shields for the engine, applied with the object of reducing the resistance of the air, and also of coverings for the spaces between the carriages fitted for the same purpose, and when we remember that the effect of the wind upon a fast train is an inportant item in the gross resistances, we may yet see such devices more generally adopted.

(I.) The Substitution of Statical for Sliding Contact.

We have already noticed that a body resting upon rollers travels faster than the rollers themselves, and therefore continually changes its position relatively to them. When the motion takes place in a straight line, the body must ultimately leave the rollers behind, and thus, as we are all aware, in moving a load in this way it is usual to carry the rollers to the front as fast as they are released behind. If, however, the body is of cylindrical form, and the rollers are sufficient in number to encircle the cylinder, it is easy to understand that, by arranging a suitable case or frame to keep the rollers in position, continuous rotation of the body may take place. If, instead of a ring of rollers, one or more rings of balls be used, with a suitable contrivance to prevent their lateral motion, the same result is attained, and we thus see the principle upon which roller bearings and ball bearings act.

Now, before proceeding to discuss these two classes of bearings separately, we must notice a theoretical defect common to both classes, which, when they are subjected to heavy pressures, becomes of practical importance, though otherwise it does not seem, from actual experiment, to be worth taking into consideration. Fig. 61 represents an end view of a portion of a roller or ball bearing, showing three rollers or balls, S S S, between the two surfaces. If these rollers or balls all turn in one direction, their sides in contact must move in opposite directions, as will be seen from an examination of the arrows in the figure. Two methods have been adopted of remedying this defect, (i) by keeping the balls or rollers apart, (ii) by making the diameter of every other ball or roller smaller than the others. The effect of this latter device is seen in Fig. 62; here the middle roller or ball, S_2, not being pressed between the two surfaces, is free to roll by contact with the sides of the full-sized rollers or balls, S_1 and S_3, on either side, and now turns in the opposite direction to that which it formerly did, as shown by the arrow in the Figure, consequently there is no sliding contact of the balls or rollers against each other.

FIG. 61.

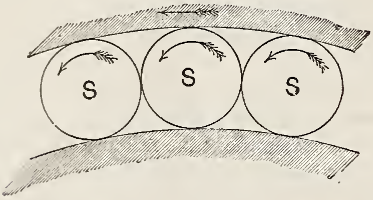


FIG. 62.

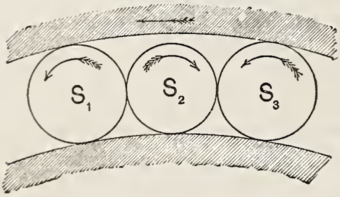


DIAGRAM OF BALL OR ROLLER BEARINGS.

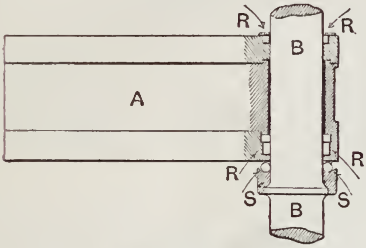
It must be noted that the term "roller" is applied to what are really small wheels, such for instance as are placed under the outer ends of dock gates to relieve the pressure upon the vertical hinge post, as well as to circular bodies where the surfaces which are moving relatively to each other are in contact at the two extremities of a diameter. Now it is true that in both cases rolling takes place, but the use of the same word to signify what are in reality two different things is objectionable, and I therefore venture to suggest the use of the word "roller wheel" for a small solid wheel supporting a load, and "roller bearing" for an arrangement of rollers such as I am about to describe.

Roller Bearings.—The roller bearing is a very old device, but though brought forward from time to time variously modified in detail, it has never come into general use, at any rate for continuous wear, with heavy pressures. George Stephenson tried an invention of this kind by a Mr. Brandreth during the construction of the Liverpool and Manchester Railway, but without any satisfactory result. In 1859, M. Brussault, of Paris, described before the Institution of Civil Engineers a form of roller bearing, the title of his paper being "On a new system of axle-boxes not requiring lubrication and without liability to heating." The axle-box of this inventor was specially designed for railway carriages, and the main feature was the use of indiarubber bands for the purpose of keeping apart the rollers. Models worked very well, and these bearings were actually tried for a time in several mills, in one case to the shaft of a steam engine of 12 horse-power making from 450 to 500 revolutions per minute, in which instance, though no grease or lubricant was used, the bearing remained cool and worked so freely that the shaft continued to revolve for three-quarters of an hour after the motive power was withdrawn. M. Brussault recounts a list of various other unsuccessfu roller bearings, dating from 1825, and explains the reason of their failure, but as nothing more was heard of his own bearing, that must now be added to the list.

For certain purposes, where the motion is slow or intermittent, and the pressures are great, roller bearings are often used. Thus Fig 63 (p. 1287) represent the door of a cotton press weighing 5 tons; A is the door and B B, the vertical axis, round which two rings of roller bearings (R R, R R) are placed, it was found that it took four men to turn it round. The weight was, however, partiall supported upon the collar shown in the Figure, and it was decided to place a ring of balls (S S) to assist in reducing the friction due to the weight of the heavy door. The result was that a weight of 35 lbs., suspended over a pulley, was found quite sufficient to keep the door moving, and one man could work it easily by himself.

It is obvious that, though a ring of cylindrical rollers could not have been used beneath the door in Fig. 63, conical rollers might have been employed. Such conical rollers were at one time extensively employed in the United States to support the pivots of swing bridges and also for railway turn-tables. A cast-iron disc had a circular groove turned in it to receive a number of steel rollers, each turned to the frustra of a double cone. A circular railway, 30 feet in diameter, was laid round the pivot for a turn-table 48 feet in diameter, this railway only coming into operation when the table is not balanced on the pivot which is supported by the conical rollers. With a weight of 14 tons balanced upon one of these bearings, the whole was revolved by a weight of *three and a half pounds* hung over a pulley by a cord attached to the periphery of the turn-table. The table is turned with heaviest engines upon it by the mere pressure of the hand, and without gearing of any kind. Pivots of the same design were fitted to two bridges each 230 feet long, and covering two openings of 100 feet each, one at Galena, and the other at Chicago.

Fig 63.



Roller and Ball Bearings.

Roller bearings have had a most important application in bicycles and tricycles, where the pressures are comparatively light and the motion continuous. Though they have been to a great extent superseded by ball bearings, I will briefly describe a few of the more important forms, for an account of which and also of the ball bearings for this purpose, I am indebted to the "Bicyclist's Handbook," by Mr. Henry Sturmey, which contains illustrations of many different kinds of such bearings. The action of the rubbing of the rollers against each other has, as I have already said, been found to detract to only a very slight extent from their effective action, but when wearing of the rollers takes place, it becomes an evil of a very serious kind, and hence various modes of adjustment have been adopted.

The simple device of having the case or framing in which the rollers are held made in two halves is not a satisfactory means of adjusting for wear, since the circular form of the case is soon lost, as the two halves are screwed closer together, and this is also the case with the Hughes roller bearing, in which a flexible split steel case, which can be adjusted by means of a set screw, is inserted in the outer frame so as to contain the balls.

The entry of dust and grit into bearings is a serious evil, as will be seen from some results hereafter given, and special devices are employed to prevent this, as far as possible, from taking place; thus in Plowright's "dust-proof" bearing the rollers are contained in a steel box with collars at each end, the whole being enclosed in an outer casing of steel. The dust is kept out upon the hub side of the bearing by this casing, which runs in a recess in the flange of the hub of the wheel, while on the crank side a second steel casing is fitted over the outside of the first, which forms a cap, and covers the boss of the crank.

Gubbins's cone and ring-bearing has high testimony in its favour. Coned rollers are used, and both axle and axle-box are plain, as for ordinary roller bearings, and an outside cap screws on laterally. Inside the case are two rings of round steel, one being on each side, and the rollers between; the outer cap is screwed up in order to adjust the bearing, and thus the rollers are pushed tighter against the axle and the outer ring. The rollers bear the friction at one point of their coned ends, and thus the rubbing which would take place on account of varying velocity ratios is avoided. The dust is excluded by means of a flange between the axle-box and screw-cap.

Silbert, Gadsby, Starling, and others have roller bearings of more or less efficient design. In that of the last mentioned maker, the axle is provided with a wide steel collar turned upon it. The rollers are of two kinds, the first being long and narrow, having the ends nearly twice as great in diameter as their central position; these roll, with their larger portions, upon the axle itself, and at the same time touch with their smaller portion, both the turned steel collar and the case, the smaller rollers are placed between the larger and keep them apart, and the friction is thus considerably reduced.

There are few cases, if any, where balls cannot be substituted with advantage for rollers, which latter, however carefully made, cannot be so satisfactorily hardened as always to wear uniformly, and when worn unequally are apt to get "across" instead of remaining parallel to each other, and soon destroy the bearing in spite of all contrivances for their adjustment.

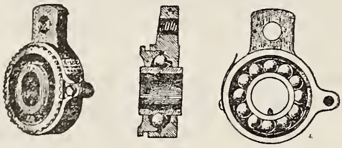


Fig. 64. Fig. 65. Fig. 66.

"Æolus" Ball Bearings.

Ball Bearings.—Although ball bearings have in some cases been applied where heavy pressures have to be sustained, their most extensive and important application is in connection with bicycles and tricycles. As in the case of roller bearings, the two great difficulties originally encountered, viz., that of adjustment and dust-proof properties, combined with ease of lubrication, seem to have been most satisfactorily overcome. There are a variety of forms of ball bearings, but probably that best known and most popular is the "Æolus" bearing of Bown. Fig. 64 shows the external appearance of this admirable invention. Figs. 65 and 66 are respectively end and front sectional views. From Fig. 66 it will be seen that twelve balls are fitted side by side, and rest upon a conical groove in a steel collar which fits the axle, the collar being fastened to the axle by means of a set screw, of which the point is shown in the figure. From Fig. 64 it will be seen that a collar is screwed into the main body of the case, having a coned end corresponding to the coned portion in the case, and the ring of balls is, by the action of the two cones, forced closer to the axle, and thus adjusted in any required manner. In Fig. 64 is seen the milled or toothed edge of the collar by which this adjustment is made by hand, the teeth of this edge at the same time enabling the adjustable portion to be locked in its place by means of another set screw shown upon the side of the bearing. Rudge's bearing is very similar to Bown's, but there are only nine balls, and the set screw which holds the adjusting plate or collar in its place is fastened to that collar. Whitehouse's and the Stanley bearing are similar in principle to the foregoing; the Club bearing, in addition to the use of two coned surfaces, is adjusted by means of a set screw, which draws together the two sides of a division made in the otherwise solid case. Hough, Green, and Granger are all inventors of ball bearings which are chiefly remarkable for their simplicity and cheapness, in which, as in all the bearings previously mentioned, there is only one ring of balls, known as single ball bearings. Double ball bearings are now much in request, from the additional steadiness thus secured in running. Humber's bearing is an example of the latter kind, the balls being kept from rubbing against each other by means of a light frame in which they are placed, this frame simply consisting of a thin cylindrical collar pierced with holes, in which the balls just fit, and which is carried round with the latter. There are many other forms of double ball bearings, such as Hillman's, the Sandringham, the Club, the Rapid, &c., each form having some special points of interest and ingenuity.

It would take too long to treat this interesting subject with anything like the fulness it deserves, for not only are ball bearings employed for the main wheel of the bicycle, which is the purpose of all those to which I have alluded, but for the smaller back wheel, for the pedals, and even for the bearing between the head and the solid portion connecting the forks and handle. To illustrate the extent to which ball bearings have been applied, I may mention that in the parts directly connected with *one wheel* of a small bicycle of the Safety type (which together with the others in the room, I am enabled to show you through the kindness of Mr. P. Louis Renouf), there are no less than 144 hardened steel balls for diminishing the frictional resistance of the various parts.

That a very small amount of wear takes place when ball bearings are properly managed is well known, but this subject has only been actually investigated a short time. Mr. C. V. Boys has recently given the results of some measurements made by him upon the actual wear due to friction taking place in such ball bearings. At the end of every 200 miles run he cleaned the balls, and then weighed them with all the possible care and accuracy that the resources of a physical laboratory would permit. The set of twelve when new weighed 25·80400 grammes, and after running 1,000 miles they weighed 25·80088 grammes, the loss being 3·12 milligrammes, or *less than* $\frac{1}{20}$ *of a grain*—that is to say, each ball in running 1,000 miles lost *only* $\frac{1}{250}$ *of a grain*. This corresponds to a wear of only $\frac{1}{158000}$ of an inch on the surface. Thus, at this rate of wear the balls would lose less than $\frac{1}{34}$ of their weight when in use in travelling as far as from the earth to the moon. Further experiments have been since made by Mr. Boys, in which the balls were not taken out for the whole distance of 1,000 miles. The balls actually showed only $\frac{1}{5}$ of the wear above mentioned, from which it would appear that the wear due to such grit and dirt as cannot be entirely excluded at first, but which does not get in after the bearing is properly screwed up, does not continue after the dirt is ground up, after which the balls literally *do not wear at all*.

These astonishing results point to the fact that ball bearings have a high mechanical efficiency, and it is extremely probable that as the cost of their production becomes less, and the mode of accuracy and quality of their manufacture improves, they will be employed not merely as now for the occasional use in such cases as for the foot of crane posts, but for many other purposes on a large scale, such, for instance, as in the thrust bearing of screw steamers, and possibly even to carry the shafting itself.*

The rubbing, or friction of sliding contact, which occurs in the various examples of roller and ball bearings that I have mentioned, takes place either from the mutual contact of the balls or rollers, or from their contact with some other portion, such as the cylindrical frame in the Humber ball bearing. In these cases, although true rolling takes place between the surfaces transmitting the actual pressure of the load, sliding contact is an unavoidable accompaniment. One principle of the wheel, as I have already explained, consists in the reduction of sliding contact between surfaces which transmit the pressure of the load. Now this sliding contact, which must always exist, may be reduced to as great an extent as desired by increasing the diameter of the wheel. The size of the wheel is, however, in most cases limited for reasons of a practical nature, but the same principle can be applied to an indefinite extent in the following manner. Suppose that the practical limit of the diameter of the wheel be reached, and that its axle be made as small as possible. Instead of allowing this to rest in a bearing of the ordinary type where sliding contact would occur, let it rest upon the upper portion of the circumference of two wheels whose axes are parallel to each other and are in the same horizontal plane but do not coincide. The axle of the first wheel will now roll upon the circumference of the other two, and the sliding contact will be less than what it otherwise would be in the proportion of the circumference of the pair of wheels (in which the axle now rolls) to twice that of their axles (because there are two of them). Thus suppose the sliding contact reduced to $\frac{1}{50}$th of its amount by the first wheel, and that the axles of the so-called "friction" wheels are half the size of the axle of the first (for there are two to sustain the load) while their diameters are the same as that of the first. Then the amount of sliding contact which finally occurs is only $\frac{1}{50} \times \frac{1}{50}$ or $\frac{1}{2500}$th of the amount which would take place if no wheels were employed. This principle is employed in the well known Attwood machine, and it has also been used for supporting the crank shaft of small foot lathes, but it has not been found suitable for application to heavy machinery. In the latter case, if the lubrication of the axles of the "friction" wheels is neglected, and the axle of the primary wheel cannot turn the former by the frictional upon their peripheries, then at their common point of contact there is, as in an ordinary bearing, sliding contact, and when once the groove, which is certain to result from this action, is cut in the peripheries of the friction wheels, their successful action becomes altogether impossible, and they must be replaced. Thus although the principle is a beautiful one, its application is confined to philosophical apparatus and purposes where the working pressures are not great.

(2.) THE PREPARATION, CHOICE, AND USE OF SUITABLE SURFACES.

The previous preparation of surfaces which have to work in frictional contact with each other is a far more important matter than many people are aware. It is frequently regarded as a correct thing to allow the result of the bad fitting of parts, which causes the imperfect contact of such surfaces, to come right in the course of time by wear, and to leave such surfaces imperfectly prepared to be worn smooth in this manner. I cannot do better than quote the opinion upon this subject of an eminent Belgian engineer, which recently appeared in the columns of *The Engineer*, November 6th, 1885. M. Van den Kerchove had his attention directed to this subject by the action of a large planing machine made by Sir J. Whitworth & Co. This machine has been doing good service in M. Van den Kerchove's works for the last fifteen years, and is still giving the greatest satisfaction, without ever having undergone the slightest repair. In the driving gear of this machine there is a shaft which, whilst planing, runs at 375 revolutions per minute, and which makes more than 1,000 revolutions per minute during the return of the table carrying the work; and although this shaft runs in solid cast-iron bearings of small length without bushes, there is not the least sign of wear in these parts. "It would almost lead one to suppose," says M. Van den Kerchove, "that these surfaces are so perfect that they slide over each other without coming into contact. Indeed, as is well-known, when one examines into the action of two correctly made surfaces, properly lubricated, sliding one upon the other, it follows that if they are well proportioned to the load they have to carry, they do not touch, since the lubricant is constantly interposed between them; and if perfect lubrication is assured, there naturally results an exceptional preservation of the rubbing surfaces, especially if one can protect them from dust, and by careful cleaning from time to time prevent the formation of dried oil." The results obtained with his machine tools M. Van den Kerchove has striven to realise in his engines. In doing this, he arrives, as he states in a small pamphlet he has distributed, at a durability of the various working parts of his engines equal to that observed in the Whitworth machine tools, and thus he has considerably enhanced the value of his engines.

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* Since delivering this lecture I have seen, for the first time, an account of the actual application of ball bearings to this purpose (*Engineering*, Aug. 6th, 1886, p. 132). Mr. Wells, of Northwich, Cheshire, more than 18 months since, applied a ball thrust bearing to the steam launch *Delaware*, the speed of the engines being in consequence increased from 177 to 187 revolutions, with the same boiler pressure and grade of expansion. A ball bearing was afterwards fitted to the steam tug *Volunteer* with very satisfactory results. With a 5-inch shaft there are two concentric circles of balls employed, one pair for going ahead and one pair for going astern, and it is stated that the bearing requires little oil, that the wear is very slight, that there is in consequence no end play on the shaft, and that the first cost is moderate.

A steam-engine, says *The Engineer*, is as much a machine capable of being made with accuracy as a lathe or a plane, and should be so made; and M. Van den Kerchove holds that those who have not had practical experience of what minute accuracy will accomplish have no idea of the benefit it confers. Take, for example, the boring of cylinders: in nine cases out of ten cylinders are neither bored truly round nor quite parallel. "A conicité," says M. Van den Kerchove, "of one-fiftieth of an inch in a cylinder will suffice to ruin a piston. To give an example. It is not unusual to have to replace piston rings once a year. This is due simply to the fact that the rings do not fit the cylinder all round. They wear where they rub. Then they cease to be true circles, and so does the cylinder, and fretting begins; whereas, if the surfaces were what they ought to be, they would, so to speak, float over each other." With perfect workmanship, M. Van den Kerchove has had one set of piston rings last for sixteen years in daily work, and at the end of that time the piston was quite tight. In another case, a horizontal engine piston worked for twelve years, at 66 strokes per minute, and at the end of that time, the greatest inaccuracy caused by wear did not exceed $\frac{1}{300}$th of an inch. "These are incontestable examples which prove that good workmanship, aided by continual care on the part of the engineer in charge, are able to augment the life of these parts of a steam-engine which have most to do, to an extent almost incredible."

I have recently come across results from two entirely different sources which illustrate in a striking manner the importance of well-fitting parts and well-prepared surfaces. A very able and experienced mechanical engineer expressed his objection to the use of the worm and ordinary cast-iron worm-wheel, for transmitting power, unless they are very carefully made and fitted, and told me the result of an experiment he had made with such a worm and worm-wheel in combination with a nut and screw, in which the loss was actually more than $\frac{29}{30}$ of the *whole power transmitted*, that is, the efficiency of the mechanism was *only* 3 *per cent.* It is true the gearing was raw and new, but still such a loss is striking, especially as the makers of the gear are a firm well known for high class work.

In contrast to the above result, I will now give the results of a series of experiments made, and kindly furnished to me by Mr. Reckerzaum, upon the worm and worm-wheel. In these experiments a dynamo-electric motor was employed to drive the worm, which was keyed upon the shaft of the motor. Upon the shafts both of the motor and of the worm-wheel were attached the pulleys of ordinary Prony brake dynamometers. The worm was of steel, and turned with a treble thread and pitch of six inches, the diameter of pitch line being also six inches. The diameter of the worm-wheel at pitch line was 15¼ inches, the angle of the teeth being 18°. Calling the shaft of the worm-wheel A, and that of the motor B, then the following is a Table of the results actually obtained :—

TABLE OF EXPERIMENTS UPON THE FRICTION OF WORM AND WORM-WHEEL.

	Weight on Brake in kilos.	Revolutions per minute.	Current ampères	E.M.F. volts.	Kilogram-metres per minute on brake.	Efficiency.
A	27	38	30	56	4504·14	·843
B	4	304	30	56	5338·24	
A	28	86	30·48	101·2	10571 12	·896
B	4	672	30 48	101·2	11800·32	
A	22	96	26·4	102·8	9271·68	·916
B	3	768	26·4	102·8	10114·56	
A	15	114	19·92	105·2	7520·99	·954
B	2	896	20·16	105·2	7881·24	

The worm was kept in gear the whole time with the worm-wheel, and if they had been thrown out of gear the efficiency would have been lower, also the pressures transmitted are not very great, still these figures, which give an average efficiency for the combination of 90 *per cent.*, show in a very significant manner what may be done by careful workmanship and the proper fitting and preparation of working parts.

We now come to the last two points in my lecture, viz., the choice and use of the most suitable surfaces for frictional contact, and I may at once say that the experience of the last fifty years has only conformed the view enunciated by Morin, and which has sometimes been called the fourth law of friction, that when lubricants are used, the extent of frictional resistance depended almost entirely upon the nature of the lubricant, and not upon the nature of the surfaces of the solid bodies between which it is interposed. Astonishing instances might be quoted, such as that mentioned previously, by M. Van den Kerchove, of the wear of such surfaces as cast-iron upon each other* when the lubrication is efficiently maintained, and what I have now to say is, therefore, chiefly concerning the choice and use of lubricants. I will first remark that although lubricants of some kind or other are always used where sliding contact takes place, their use does not appear to diminish the resistance to the rolling of two surfaces over each other, and to secure the least amount of frictional resistance to rolling contact the surfaces must be as hard and smooth as possible.

In the choice and application of lubricants, a great advance has been made in recent years. A vast number of substances have been carefully examined with reference to their lubricating properties, among them being lard and the oils of sperm, neat's foot, fish, olive, cotton seed, rape seed, cocoa nut, elaine, castor, linseed, &c., as well as mineral oils of all kinds, and the properties of solid substances, such as graphite, asbestos, and soapstone. Fluid lubricants have been tested for density, specific gravity, viscosity, gumming, and drying; by fire tests, by means of "oleography," and by specially constructed testing machines.

I have recently given a brief sketch of what has been done in this direction,* and have shown how carefully lubricants are now prepared and tested.

It may be necessary to ascertain what an oil or lubricant actually is, but it is much more frequently required to know whether it is pure or not, and the work of the above-mentioned chemists and others has resulted not only in a knowledge of facts, such, for instance, as that chlorine turns animal oils brown and vegetable oils white, but also in certain systematic methods of test. The first step is to place the lubricant in one or other of certain defined classes; next, by other tests, to place it in its proper sub-divisions, and finally to analyse it, with a view to the determination of its constituent parts. It must be remembered that by far the greater proportion of lubricating oils are ostensibly mixtures, vendors of such oils holding (as, for instance, Mr. Veitch Wilson in the paragraph previously quoted) that such mixtures produce the best results.

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* Mr. Goodman, in the paper I have already referred to in Lecture I., states that on the Brighton Railway there are many cast-iron eccentric straps working on cast-iron sheaves, which have been running constantly for twelve or thirteen years without requiring the slack to be taken up, their surface velocity being 900 feet a minute, representing in thirteen years a distance of at least 100,000 miles passed over by the surfaces. This result, the author remarks, being due to the thoroughly good system of lubrication adopted.

* "Proceedings of the Liverpool Engineering Society, Oct. 28th, 1885." The reader is referred for the most complete collection of facts concerning lubricants to the new work of Professor Thurston, "Friction and Lost Work," Wiley and Sons, New York.

Thus chemical tests, though sometimes employed for examining the actions of lubricants on metals, chiefly tell what the lubricant *is*, and are of little practical importance compared with physical and mechanical tests, which tell rather what the lubricant *does*.

The chief physical tests are the determination of (1) density, (2) the effect of heat, (3) the gumming and drying properties of a lubricant.

(1.) The density or specific gravity of an oil is sometimes an important matter, as there is a considerable difference between various oils, but the determination is easily affected by ordinary methods.

(2.) The effect of heat on the nature of a lubricant must not be confounded with the effect of rise of temperature on frictional resistance. The application of heat is important rather in connection with mineral oils which vaporise, and compounds into which mineral oils largely enter, than with animal aud vegetable oils which thicken and decompose.

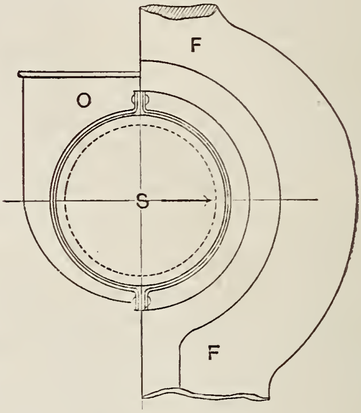
There are two points for consideration in connection with the former class of oils, one being the amount of evaporation taking place at temperatures not exceeding the boiling point of water, the other the actual point at which the ignition of the vapour gives off takes place. Mr. Wilson, in his paper, states that, though many oils, considered good, lost 5 per cent., and one or two samples 10 per cent., in a 10-hours' test at 212° F., yet, on the other hand, many oils lost nothing at all. The second point is, however, much more important, and there are strong reasons for attributing several recent conflagrations and consequent destruction of mills to the ignition of the lubricants used in them. The "fire-test" thus becomes an important one. There are several pieces of apparatus for the purpose, the principle of them all being simply to heat the oil until the vapour given off ignites on the application of a light, the temperature of ignition or "flash point" being observed by means of a thermometer. The neatest instrument for the purpose is that of Bailey, in which the oil is heated in a copper vessel about three quarters full, the vapour from which, issuing laterally, comes in contact with the flame of the heating lamp or Bunsen burner. This is a more satisfactory arrangement than the application at intervals of a light to the orifice. There are many oils which flash at 180° F., some at 150° F., but an oil should never be used for lubricating purposes which flashes at a point below 250° F., some of the best mineral oils vapouring at 600° F.

(3.) The gumming and drying properties of oils may be simply tested by allowing samples to flow down an inclined plane, when the nature of the oil becomes manifest by the rate at which it travels and the distance it moves.

Other modes of physical tests are employed, but which I need not refer to.

I will now very briefly explain the action of such of the various testing machines as I am able to exhibit to you, which machines really show what the working properties of a lubricant are, by running a portion of it under various conditions of pressure, velocity, and temperature with results such as I have already referred to in my second lecture.

Fig. 68.



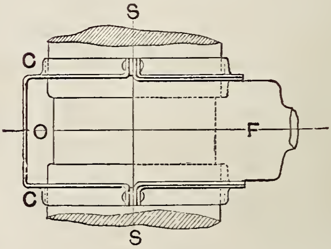


Fig. 69.

Oil Bath Bearing.

Time compels me to treat in a brief manner the last point I have to bring before you, viz., the manner of using lubricants and the various kinds of lubricators, of which there are now so many varieties, and in the design of which much ingenuity has been expended.

The great advantages of a continuous supply of lubricant were fully proved by Mr. Beauchamp Tower's experiments with the oil bath bearing. Fig. 68 shows an elevation, and Fig. 69 a plan, of an oil bath bearing designed by Mr. Edward

Shaw for a journal 3″ diameter by $1\frac{1}{4}$″ wide, in which a pressure of 1,200 lbs. acts in the direction of the arrow (Fig. 68). F F is the frame of the machine, of cast iron, against which the cast iron shaft, S S, works, the lubricant being contained in the box, O, and prevented from escaping along the shaft by the adjustment of the sides of the box at C C. This shaft has been working for several months with neat's-foot oil, at a surface velocity of 150 feet per minute, and does not show any signs of wear.

As a rule, however, oil bath bearings are not possible, and arrangements must be made to supply the lubricant either continuously or at regular intervals. A number of "sight-feed" lubricators have been introduced, in which the amount of the supply can be watched. Figs. 70 and 72 shows two views of one of the simplest lubricators of this kind for marine engine bearings. This lubricator in which the falling drops of oil can be seen as they pass through the glass tube in the neck is the invention of Mr. Baird, and is manufactured by Messrs. W. H. Bailey and Co., to whose illustrated catalogue I am indebted for the figures of the various lubricators. Fig. 71 shows the way in which these lubricators are used, four of the lubricators being shown on a small scale fixed to the main shaft bearing, two above them being used to lubricate the crank-pin bearing.

Fig. 70.

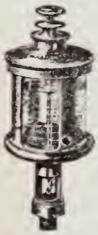


Fig. 71.

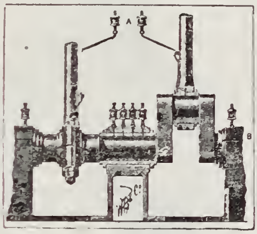
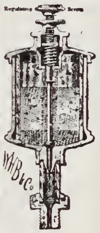


Fig. 72.

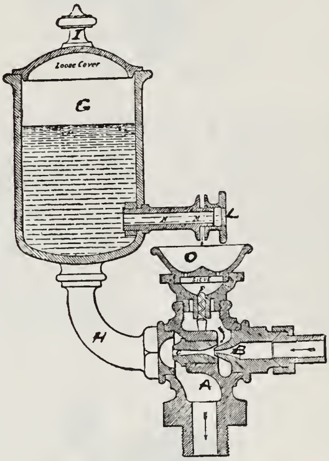


Sight Feed Marine Engine Bearings.

The "Oleojector" (Fig. 73) is a very ingenious lubricator, the invention of Mr. Royle. The principle of action is that a small jet of steam taken from any high pressure part of the engine is allowed to play into the cylinder, into which it carries the lubricant even against considerable pressure.

A is the body or injector portion provided with the cones, B and C, which are fixed in position and require no adjustment. The inlet cone, B, is connected to the main steam pipe or other source of steam supply, and the rear of the outlet cone communicates with the engine cylinder about the middle in horizontal engines, and the upper end in the case of vertical engines. The suction produced by the small jet of steam passing these cones as the piston reciprocates on the cylinder is utilised to draw the lubricant into the cylinder, which falls on to the cup, O, in a measured quantity. A valve, F, is arranged to prevent the return of the oil. G is a cistern or receiver for containing the lubricant, and which is provided with a loose cover, I. The regulator, L, controls the quantity of lubricant (falling drop by drop out of the cistern, G, on to the cup, O) to the greatest nicety. At each successive period of low pressure in the cylinder a jet of steam passes through the cones, B and C, and the effect thereby produced opens the valve, F, and draws in any oil or other lubricant that has been fed to the cup, O, and carries it into the cylinder in the form of a fine spray. At the period of high pressure in the cylinder, the valve, F, closes, and so prevents the oil returning.

Fig. 73.

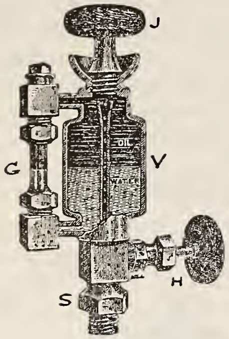


The Oleojector.

Figs. 74 and 75 (p. 1294) represent two cylinder lubricators of Mr. W. H. Bailey.

In Fig. 74 the oil reservoir V communicates with an upright glass gauge tube, G, by means of two passages, one at the top and one at the lower end. A passage leads through the neck, S, of the lubricator and terminates inside the reservoir near the top, in the form of a tube, which widens out to a slight extent. The screw plug, J, is for filling the lubricator, and H is for regulating the supply of oil through the neck, S. The oil floats on top of the water in the lubricator, and the gauge glass, G, shows the level of the division.

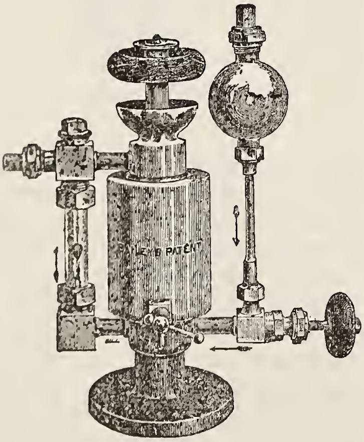
Fig. 74.



Cylinder Lubricator.

Fig. 75 shows a slight feed lubricator, which is used to supply oil to the main steam pipe. This lubricator consists of a main reservoir, communicating at the bottom with a glass tube, through which the oil passes upwards on its way to the steam. A steam-pipe, on which is a hollow globe (shown on right hand of figure), leads to the lower end of the lubricator, and the oil by this means forced out of the reservoir up the glass tube, in the form of drops, the rate of supply of which is regulated by the small stop-cock, shown in the right-hand lower corner of the figure. The value of a lubricator, such as the above, in which the oil supply can actually be seen, is too obvious to need explanation.

Fig. 75.

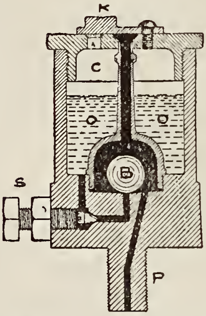


Sight Feed Lubricator.

Fig. 76 represents Threlfall's lubricator for motion bars of locomotives.

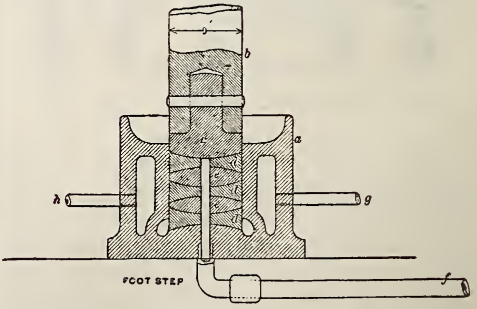
The oil reservoir, O, O, has an inner chamber containing a brass valve, B, which fits on a concave seating. Leading from the oil reservoir to the inner chamber is a passage, terminating in the centre of the ball valve seating. From the inner chamber another passage leads through the shank of the lubricator. The pipe running from the valve chamber through the lid is for the purpose of admitting air, and for flushing the lubricator and oil passages when the machinery is at a standstill. The aperture in the lid at C is for filling the lubricator with oil, both this and the pipe mouth being protected by the hinged slide, K, so that dust, ashes, or other deleterious substances cannot get into the lubricator. The valve, B, regulates the supply of oil passing from the reservoir into the valve chamber. When the locomotive is in motion, the ball rolls loosely on its seating, thus allowing oil to pass down the shank, P, of the lubricator, and so passes on to the part which is to be lubricated.

Fig. 76.



Lubricator for Locomotive Motion Bars.

Fig. 77.

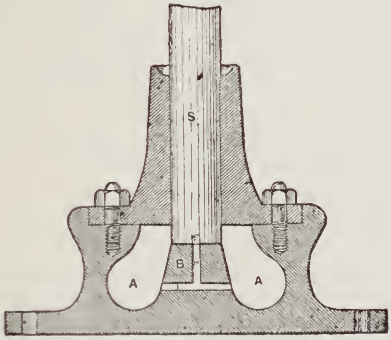


Method of Lubricating Foot-step.

A form of bearing used in a cotton mill at Darwen, in Lancashire, is shown in Fig. 77. The mill is six or seven storeys high, and, like most of the mills in that country, was geared with massive gearing, a vertical shaft being employed with a pair of bevel wheels at each floor. This shaft was 9″ diameter at bottom, and finished with a 5-inch shaft at top. Altogether the weight of shaft and gears was very excessive. They tried several plans to make a foot-step that would not heat, and finally adopted this one. The idea was to get a hydraulic pressure on the bottom of the shaft by means of hydraulic pumps and accumulators, and provide a stream of cold water in the annular space, so as to cause circulation and cool the bearing. Whatever pressure was needed on the end of the shaft was got by regulating accumulator and pumps, the shaft being relieved from the bearing to that extent. The use of the discs of different metals was, as will be understood, to prevent the surfaces from cutting, and at the same time, if one disc should cut, any one of the others could begin to operate. Mr. Walker, who is a member of the American Society of Mechanical Engineers, described this bearing, and says, "I know of no bearing of this kind so large, and, at the same time, so successfully applied."

Fig. 78 shows a bearing described by Mr. Durfee before the American Society of Mechanical Engineers. The bearing and footstep are supposed to be formed of cast iron, with an oil well. Directly through the centre of the support, B, on which the shaft, S, revolves, a vertical hole, H, is drilled, intersecting a horizontal hole, I. On the end of the vertical revolving shaft, S, there is a groove, F, cut right across the centre of the shaft. The oil well being full of oil, as the shaft, S, revolves, the centrifugal force tends to throw every particle of oil out of the groove, F. The consequence is, that there is a continual circulation of oil through the holes, H, I, and the groove, F, being cut across the shaft, distributes the oil over the upper surface of the shaft support, B, at every revolution.

Fig. 78.



Method of Lubricating Foot-step.

The brief sketch I have given of the subject of lubricants, and their mode of application, does not, I am afraid, do justice to its importance, but no general treatment of the question of "Friction" would be complete without some attempt to show the advance which has been made towards raising the subject of lubrication to the dignity of a science.

Indeed, in bringing this course of lectures to a close, I must confess that, so far from having exhausted the subject, I have only been led to realize its magnitude, and if I am encouraged to think that the labour bestowed upon the preparation of these lectures has been of any value, I am, at the same time, led to realize how imperfect my treatment of the whole subject has been. My thanks are due to a number of gentlemen for assistance of various kinds, which I have, in the course of the lectures, endeavoured to acknowledge. But I wish specially to thank Mr. Lionel Pearce, for enabling me to exhibit to you his friction still, and for illustrations of it; Mr. P. Louis Renouf, for procuring various samples of bicycle and tricycle ball bearings; and my students, Mr. A. Simms and Mr. Robert Holt (Whitworth Scholar) for their kind and valuable aid.

Miscellaneous.

COLONIAL AND INDIAN EXHIBITION.

The Exhibition was finally closed on Wednesday night, 10th instant, at eleven o'clock. Owing to the wetness of the day, the number of visitors was small, not amounting to more than 10,409. The grand total of visitors amounts to 5,550,749, or an average of 33,846 per day. The figures in respect to the previous Exhibitions were as follows:—1885, Inventions, 3,760,581, an average of 23,071 per day; 1884, Health, 4,153,390, 27,505 per day; 1883, Fisheries, 2,703,051, 18,387 per day. To the record of these numbers may be added the attendances at the Liverpool and Edinburgh Exhibitions of the present year. The Liverpool Exhibition was opened by the Queen on the 11th May, and closed on Monday, 8th instant. The attendance on the closing day numbered over

52,000 persons, and the total number of visitors since the opening has been 2,682,516. The total number of visitors to the Edinburgh Exhibition was 2,769,632.

A meeting of a Committee of Agents-General, and of the Executive Commissioners of the Colonial and Indian Exhibition, was held on October 24th, when the following resolution of thanks to his Royal Highness the Executive President and the Executive Secretary were passed. It was moved by Sir Charles Tupper and unanimously agreed to :—

"That the Executive Commissioners here present desire to return their dutiful thanks to the Prince of Wales for his address; to offer their congratulations to his Royal Highness upon the complete attainment of the high purpose for which he called the Exhibition into existence; to express the deep obligations of their Governments for his constant exertions for the advancement of the best interests of India and the colonies; and to assure his Royal Highness that the gracious interest he has shown in the success of the Exhibition from first to last has been witnessed with grateful appreciation by her Majesty's Colonial and Indian subjects."

It was also moved by the High Commissioner of Canada (who is acting as chairman of the committee by his Royal Highness's request) and likewise unanimously agreed to :—

"That the best thanks of the Executive Commissioners are due to Sir Philip Cunliffe-Owen, for the able, courteous, and considerate manner in which he discharged his onerous duties as secretary to the Royal Commission, and for the cordial assistance he has ever given to his colleagues; and that the chairman be requested to express to the Prince of Wales their unanimous opinion that to the exertions of Sir Philip Cunliffe-Owen and his staff is in a large measure due the signal success which has been attained."

ADELAIDE JUBILEE INTERNATIONAL EXHIBITION.

The Queen has appointed a Royal Commission in connection with this Exhibition, to be held at Adelaide in 1877, to consist of H.R.H. the Duke of Cambridge, the Duke of Manchester, the Marquis of Normanby, the Earl of Rosebery, the Earl of Carnarvon, the Earl of Dunraven, Earl Granville, Viscount Cross, Lord Thring, Hon. Edward Stanhope, Sir James Fergusson, Sir Henry T. Holland, Sir John Rose, Hon. C. W. Fremantle, Sir Frederick Leighton, Sir Richard Owen, Sir Philip Cunliffe-Owen, Sir Joseph D. Hooker, Sir John Gilbert, Sir James D. Linton, and Colonel Donnelly.

The first meeting of the Royal Commission took place at the Horse Guards on Monday, 8th inst., the President, the Duke of Cambridge, in the chair. It was resolved that the Secretary, Sir Herbert Bruce Sandford, should proceed to Adelaide in March next, as the official representative of the Commission, and remain throughout the whole period of the Exhibition; and as in the case of the Melbourne Exhibition of 1880-81, watch over the interests of British exhibitors, particularly in connection with the appointment of jurors and the making of awards. The offices of the Royal Commission for the Exhibition are at 11, Henrietta-street, Covent-garden. Applications for information and for forms for space should be made by intending exhibitors to the Office of the Adelaide Exhibition Committee, at the Agent-General's for South Australia, 8, Victoria-chambers, Westminster.

MINING IN SPAIN.

The soil and rock of the Peninsula abound in mineral wealth, and her Majesty's Secretary of Legation, at Madrid, in his last report to the Foreign Office, says that, were capital and enterprise forthcoming, Spain would have no occasion for importing either ores or manufactured metals. The following is a comprehensive list of minerals common to Spain. Iron and argentiferous iron, arsenical pyrites, ochres, lead and argentiferous lead, copper and argentiferous copper, silver, gold, tin, zinc, copperas, alkaline salts, quicksilver, antimony, cobalt, manganese, coprolitic earths, sulphate of baryta, alum, graphite, amber, anthracite, bitumen, common salt, sulphate of soda, topaz, phosphate of lime, lithographic limestone, fluorspar, steatite, kaolin, asbestos, argillite or plastic clay, sulphur, coal, lignite, peat, bitumenous shale, asphaltum, petroleum (traces of), naphtha, and a variety of mineral waters. According to the latest statistics of the Director General of Agriculture, Industry, and Commerce, the following additions were made in 1882 to the registered mining properties, viz., 539 concessions of all kinds, embracing an area of 24,435 acres. On the 31st December of that year there was a registered total of 17,346 mines, 96 partly worked or temporarily abandoned mines, 13 slag refuse heaps, and 35 mines under examination, over a total area of 1,299,345 acres. The operatives employed by the remunerative concessions amounted to 61,068 men, 2,404 women, and 10,933 boys, making a total of 74,405, being 8,211 more than in 1881. The steam power was represented by 11,387 horse-power. The mines—as distinct from the total concessions—in activity, employed 11,205 men, 804 women, and 2,127 boys; total, 14,136 operatives. In these mines were working 67 hydraulic and 2,218 horse-power respectively. In 1881, there was an increase of production of the following minerals, viz., 1,223,612 tons of iron ore, 9,442 tons of silver ore, 264,901 tons copper ore, 14,442 tons zinc ore, 3,118 tons quicksilver ore, 26 tons antimony ore, 9,325 tons sulphate of soda ore, 1,109 tons phosphate of lime ore, 1,405 tons alum ore, 7,346 tons sulphur ore, and 387 tons of asphaltum ore. Sulphate of baryta remained stationary, and, as regards gold and silver ores, as well as that of tin, a slight increase was observable. On the other hand, there was a falling off in the following minerals, viz., 1,120 tons of lead ore, 2,230 tons of argentiferous lead ore, 30 tons of lead and zinc, 30 tons of argentiferous copper, 120 tons of nickel, 62 tons of cobalt, 2,539 tons of manganese, 37,897 tons of common salt, 5,893 tons of coal, 734 tons of lignite, 400 tons of peat, and 366 tons of kaolin. The increase of raw metals was as follows:—5,670 tons of pig iron, 1,961 tons of wrought iron, 22 tons of silver, 282 tons of zinc, 8 tons of antimony, 671 tons of crystallised sulphate of soda, 56 tons of alum, 1,189 tons of sulphur, 256 tons of asphaltum, and 8,368 tons of hydraulic cement. The production of sulphate of baryta remained unchanged. The decrease in the production of raw metals in 1881 was as follows:—1,942 tons of lead, 391 tons of argentiferous lead, 629 tons of copper, 107 tons of quicksilver, and 1,800 tons of crushed alabaster. The total value of the production was £4,553,677, showing an increased value over the previous year of £233,666. In addition to the above, old rails were exported to the following countries:—England, Italy, Morocco, Portugal, and the United States, in all 27,908 tons, valued at £79,816. Te Ceuta, France, Cuba, the United States, Mexico, and the Philippine Islands, about two tons of steel weapons were exported, valued at £1,126; and to France, Cuba, Porto Rico, Ecuador, Mexico, Colombia, St. Domingo, Uruguay, Venezuela, the Danish West Indies, the Dutch Possessions in South America, and to the Philippine Islands, about sixty tons of firearms, valued at £70,892.

WHEAT CULTIVATION IN INDIA.

The United States Commissioner of Agriculture, in a recent report on the wheat cultivation of India, says that the Indian farmer has scarcely any tools, and what he has are of the simplest kind. By a very crude implement which is intended to perform the work of a plough, the land is torn up. This implement consists of a triangular piece of wood, about 18 inches in length and 6 inches in diameter at the larger end, the other being pointed. On the flat side of this piece of wood a groove is made, into which a flat piece of iron a foot in length, an inch wide, and half-an-inch thick, is inserted and held in its place by a staple. The staple underneath does not interfere with the rooting, and the iron bar, which is pointed, serves as a nose or point to the plough. The larger end of this triangular piece of wood is fixed into an upright stick, the latter about 3 feet in length, at the top of which is a wooden pin for a handle. About 18 inches from the ground a strip of board 3 inches wide, an inch-and-a-half thick, and 8 feet long is inserted into the upright stick, and serves as a beam and tongue. The yoke is a straight stick 6 feet long, 3 inches in diameter, with four wooden pins, each 6 inches long, one on each side the neck of the bullocks. A small hempen rope or grass twine goes under the bullocks' necks to keep the yoke in its place. The beam of the plough has a few notches under it near the end, and is fastened to the yoke by a small grass rope or twine. The plough makes no furrow, but simply roots or tears up the soil, and the ploughman, with a whip or goad in one hand, the other holding the wooden pin in the upright stalk, walks by the side of the plough. The utmost that can be done with this rude implement is to tear up about three-quarters of an acre a day, and the land has to be ploughed in this way a number of times, especially for the more substantial crops. The only other implement used is a log or slab of wood, 6 or 8 feet long, drawn sideways across the field by one or two pair of cattle, to crush the clods and smooth the surface. After the land is broken up the last ploughing takes place, when a man or woman sprinkles the seed from the hand into the furrow. The reaper consists of a blade of iron 6 inches in length, 1 inch in width, and curved like an old-fashioned sickle, with a notched edge and a short handle. The harvester sits upon his heels, cuts a handful of straw, which he lays down, then moves along without rising, cutting about one-twelfth of an acre a day. After him comes a binder, who gathers up the grain and binds it into sheaves, which are then carried to the threshing floor. The threshing machine consists of a floor, a stake, a number of cattle, and a driver. The grain straw is piled round the stake in the floor, the cattle are connected by a rope tied to their horns, and one end of the rope fastened to the stake, and the driver keeps them moving until the straw is trampled very fine, into what is called *bhoosa*. The winnowing machine is a scoop about 18 inches wide, made of reeds, and in shape like a large dust-pan. This is filled with grain and chaff, and held in the wind, so that the chaff falling from it is blown from the grain. If there be no wind, two men take a blanket—one at each end—and wave it between them, while a third shakes the grain from the scoop. After threshing, the *bhoosa* is put in thatched ricks or bins, or in a corner of the huts, or mud-walled houses. In preparing the fields for a crop of wheat, care is taken to manure them in May or June, previous to the rains. After the field has been ploughed, a flock of sheep or a number of cattle are herded on the field at night. The least number of times the land is ploughed is ten, and the greatest number thirty. After the end of September the sowing takes place. First, a Brahmin is consulted, if the farmer is a Hindoo, to fix the auspicious time, and, this being determined, he appoints a man to do the first sowing, after which anyone may sow the seed, but not before. The farmer's wife, on giving out the seed, reserves a little, to which she adds more grain, and then distributes it to the officiating Brahmin, the ploughman, and the labourers. The seed is carried in a basket, and sprinkled behind the plough with the hand. The average amount of seed for an acre is one hundred and fifty pounds. In some districts the wheat is carefully weeded, the weeds serving as food for the people, and the grass as fodder for the cattle. In many places the fields have to be watered, and this has to be done usually about three times—first, after the seed germinates, then when the wheat is about to blossom, and finally when the wheat is in the ear. The harvest for wheat sown in October takes place in March, but usually the harvest time is in April, the wheat ripening in about four months.

CULTIVATION OF TEA IN FORMOSA AND CHEHKIANG.

Tea cultivation in North Formosa is chiefly confined to the hills, and though a good supply is grown within three miles of Tamsui, the main centre of the production is in the hills some twenty miles to the south. The soil there is generally a kind of reddish yellow sticky clay, in wet weather resembling cream, and extremely slippery; this is on the lower and middle slopes, that of the upper is inferior, and these slopes are often so steep that it is difficult to understand how it is possible to till them. The Commissioner of Customs at Tamsui says that everywhere one is struck by the amount of new ground which is being broken up in order to set more tea. The first thing is to clear away the long grass and brushwood, cutting down the trees, digging up the roots, burning them, and planting indigo. When this plant has run for some little time it is replaced by tea, and in the matter of planting, the plan adopted in Formosa differs very considerably from that followed in many of the other tea districts. There a large quantity is produced by means of slips or cuttings, as well as by seeds, and no manure is used, while in the Ningpo and Tientai districts seeds alone are employed. In the latter district several holes are made, and five or six seeds are dropped into each and covered up, and liquid manure or wood ash is then applied. During the following three years the ground is carefully weeded and manured, at the end of this period the young plants are separated from the older ones. If carefully tended and pruned of the old wood, a bush will last many years. The first picking takes place generally in February, and the second in May. The soil is light and friable, being composed of a mixture of sand and vegetable mould. In the Ningpo district the most luxuriant tea is that of the alluvial plain, and is grown between rows of mulberries. At Tientai, in the province of Chêhkiang, Commissioner Hancock states that the finest tea is grown, the soil being light and sandy, corresponding in a great measure to that of the Bohea mountains. The following is the method of cultivation practised. Pieces of bamboo about six inches long are placed in holes made in the ground, and about fifteen seeds put into each tube, the tubes are then filled up with earth, this operation being performed in the month of September. In the following June some of the seeds having germinated, appear as small plants at the top of the bamboo which is then removed. The growth is at the rate of about four inches a year, and the first picking takes place four years after planting. There is only one picking each year, in April, but lower down on the mountains the first takes place when the plants are three years old, and there are as many as three in the year. The plants are not considered to have attained maturity until they are ten years old; they are never changed, but from time to time the decayed wood is cut away. In the Formosa tea plantations little attention appears to be paid to drainage on the steepest slopes; the furrows, instead of being run in a slant, are generally carried horizontally, in consequence of which a more direct barrier is placed against the descent of water during heavy rains, so that in some places where the soil is stiff, the water remains, while in others the soil is swept away. The distance at which the plants are set apart differs very considerably, according to district—in some places they are placed at intervals of thirty inches, which, allowing for the spread of each bush and the necessary ploughing between the rows, is as close as practicable. In Formosa the advantages of soil and climate are so great that there are often no less than seven pickings in the course of the year, the three first being the best, while in the Ningpo district there are never more than three.

ECONOMIC PRODUCTS OF MADEIRA.

Madeira grows beef of fair quality, but the mutton is very poor. The bulk of the animal food consumed by the people is derived from the sea. In fine weather the fisheries engage many hands. The common table fish mostly caught embrace herring, cod, mullet, mackerel, horse mackerel, braise, groper, and tunny, the last-mentioned sometimes attaining a weight of 300 lb. Cod is largely salted. The common eel, found in a few streams, is the solitary representative of fresh water fishes. Among reptiles the loggerhead turtle (*Caouana caretta*) is captured for conversion into soup, but is far inferior to the West Indian green turtle.

The local production of grain (wheat, maize, and barley) does not suffice for native needs. Amylaceous foodstuffs comprise potatoes, sweet potatoes, chestnuts, and *Colocasia esculenta;* other vegetables are beans, cabbages, carrots, gourds, onions, &c. Tropical fruits include bananas, and pine apples (exported to England), apples, custard apples, figs, guavas, mangoes, peaches, and pears. Dates grow in small numbers, but are very inferior; indeed the quality of most of the fruits is not first-class. The sugar-cane grows well below 1,000 ft., and where water abounds, and the product is an article of export. The combined effects of oïdium and phylloxera have greatly reduced the once flourishing wine industry. Nevertheless, many wines are cultivated by peasants, who sell their must to a merchant, who is also a manufacturer, and under whose care the preparation of the wine is completed. The ordinary wines are *tinta* and *verdelho*, from black and white grapes respectively. A mixture of them constitutes the full-bodied wine, of excellent quality and bouquet, known in this country as "Madeira." Other varieties of grape produce the high-class wines called *bual*, *sercial*, and *malmsey*. Tobacco is grown in small quantities, and made into poor cigars. The fuel of the inhabitants is derived from planted tracks of *Pinus pinaster*. The fine scented cabinet wood of *Juniperus oxycedrus* is now almost a thing of the past. The archil weed *(Roccella tinctoria)* grows on the rocks, and is exported for dyers' use.

Obituary.

JAMES GIBBS, C.S.I., C.I.E.—Mr. Gibbs, whose death occurred last week, was the son of the late Alderman Michael Gibbs, who held the office of Lord Mayor in 1845. He was born in 1826, and was called to the Bar by the Benchers of the Inner Temple in 1864. Subsequently he held several important offices in India, having been Assistant Judicial Commissioner and Acting Assistant Political Commissioner in Scinde under Sir Bartle Frere, senior Judge of the High Court of Bombay, member of the Government, and Chancellor of the University of Bombay. More recently be was senior member of the Supreme Government of India under the last three Viceroys. At the request of the Marquis of Ripon, Mr. Gibbs undertook, in addition to his other duties, the management of the Indian Ecclesiastical Department. Mr. Gibbs read a paper before the Indian Section of the Society of Arts on April 2nd last, on "The History of Archæology in India." He was elected a member of the Society in the present year.

MEETINGS FOR THE ENSUING WEEK.

TUESDAY, Nov. 16...Civil Engineers, 25, Great George-street, S.W., 8 p.m. Messrs. Kinipple, Kyle, Carey, Strype, Willett and Langley, papers on "Concrete as applied in the Construction of Harbours at Quebec, Colombo, Newhaven, Wicklow, Fraserburgh, and Lowestoft."

Statistical, School of Mines, Jermyn-street, S.W., 7¾ p.m. Mr. J. S. Jeans, "Cost and Conditions of Railway Traffic."

Zoological, 11, Hanover-square, W., 8½ p m. 1. Col. C. Swinhoe, "The Lepidoptera of Mhow, in Central India." 2. Dr. R. W. Shufeldt, "Contributions to the Anatomy of *Geococcyx californianus*." 3. Mr. R. Lydekker, "Description of three Species of *Scelidotherium*." 4. Mr. G. A. Boulenger, "Two European Species of *Bombinator*."

WEDNESDAY, Nov. 17...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. Opening Meeting of the Session. Inaugural Address by Captain Douglas Galton, Chairman of the Council.

Institute of Bankers, Theatre of the London Institution, Finsbury-circus, E.C., 6 p.m. Mr. Claremont Daniell, "The Drain of Gold to India, its Effects on Trade and the Remedy."

Meteorological, 25, Great George-street, S.W., 7 p.m. 1. Mr. Charles Harding, "The Gale of October 15th-16th, 1886, over the British Islands." 2. Mr. Thomas G. Benn, "The Climate of Carlisle." 3. Mr. E. T. Dowson, "Results of Hourly Readings derived from a Redier Barograph at Geldeston, Norfolk, during the four years ending February, 1886." 4. Mr. R. L. Holmes, "Results of Observations taken at Delanasau, Bua, Fiji, 1881-1885."

Patent Agents, 19, Southampton-buildings, W.C., 7½ p.m. Discussion on Mr. Newton's paper.

Geological, Burlington-house, 8 p.m. Papers by Prof. Hughes and Mr. F. Rutley.

THURSDAY, Nov. 18...Linnean, Burlington-house, W., 8 p.m. 1. Dr. Maxwell Masters, "Floral Conformation of *Cypripedium*." 2. Rev. A. Eaton, "Recent *Ephemeridæ*. (Part V.) 3. Mr. J. G. Baker, "Further Contributions to the Flora of Madagascar." 4. Mr. S. Hanley, "Supposed Precedence of Hivas in Genus Conus."

Chemical, Burlington-house, W., 8 p.m. 1. A Spectroscopic Study of Dyes and Colours. 2. Prof. W. N. Hartley, "Note on Naegeli's Theory of Fermentation." 3. Dr. Divers and Mr. T. Haga, "The Reduction of Nitrites to Hydroxamina by Hydrogen Sulphide." 4. Dr. Japp and Prof. N. H. J. Miller, "The Preparation and Saponification of Hydrocyanides of the Diketones."

National Indian Association, Essex-hall, Essex-street, Strand, W.C., 3½ p.m. Mr. Gulam Mohamed B. Munshee, "Marriage Customs in Western India."

FRIDAY, Nov. 19...Civil Engineers, 25, Great George street, S.W., 7½ p.m. (Students' Meeting.) Mr. Arthur J. Russell, "Diamond-Mining in Parana, South Brazil."

CONTRIBUTIONS TO THE READING-ROOM.

The Council beg leave to acknowledge, with thanks to the Proprietors, the regular receipt of the following Transactions of Societies and Periodicals during the year.

TRANSACTIONS, &c.

Aeronautical Society, Annual Report.
American Philosophical Society, Transactions.
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